The
Tropical Agriculturist
April, 1928.

Editorial.

Paddy Investigations.

IN the present number of the *Tropical Agriculturist* are reproduced the results of certain investigations made with Ceylon rices. These results have been secured from tests which have been made as part of the programme of work of the Economic Botanist in connection with the selection of high yielding strains of paddy.

The milling tests were made by the Economic Botanist and the chemical analyses were carried out in the laboratory of the Agricultural Chemist. The ordinary milling methods of the village agriculturist were adopted and it is clear that the outturn of rice from parboiled paddy is larger than from raw rice and that breakage is greatly diminished particularly in a pure-line strain.

The chemical analyses indicate that Ceylon paddies are richer in proteins and minerals than the paddies of India and elsewhere and that the pure-line paddies show higher nutritive constituents than the mixed varieties. Parboiling affects only to

a very small extent the chemical composition of rices, but the fat content shows a slight fall. The bran or residue after the second pounding of paddies contains larger proportions of the fat protein and phosphoric acid. The polishing of rices results in much greater losses of fat and phosphoric acid than when preparation is done by the village method of pounding.

These results confirm the experience of other countries and confirm the superior value of unpolished rice and the high value of rice bran as a cattle food. They are also of interest as indicating the possible increased value of pure-line paddies to any rice-milling industry and to the necessity of watching the requirements of the mill-owners where such an industry exists.

The other experimental data presented deals with germination tests and with the effect of attack by paddy moth and weevil on the germination of seed. These are of direct value to all who keep seed for sowing purposes and should be studied carefully. The value of smoking seed paddy for the *Maha* season during the first two months after harvest is confirmed whereas smoking of *Yala* paddies is valuable only if the seed is to be sown immediately after harvest. Old seed should be treated in a different manner than new seed and it has been found that light-glumed seed germinates quicker than the dark-glumed seed.

The experiments to test the amount of insect attack on stored seed were designed to secure information regarding the storage of seed at paddy seed stations and the precautions necessary to secure satisfactory storage.

The above investigations only indicate a portion of the work which remains to be done in connection with paddy in Ceylon. They indicate some of the lines of research necessary for obtaining accurate data and it is only when such data are available that sound progress in the improvement of paddy cultivation can be effected. There are many who are inclined to misunderstand the value of research and there are others who feel that improvements in paddy crops of Ceylon's existing paddy-fields can be attained. There are many factors which militate against the increase in paddy crops taking place. Land tenure systems, conservatism of cultivators and several other drawbacks contribute to a slow progress of improvement. These will disappear in time and then greatly increased crops should be possible. A real interest in paddy improvement is being awakened.

Original Articles.

The Chemical Composition of Some Ceylon Paddies, Rices and Milling Products.

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RICE is the staple food of the greater part of the indigenous population of Ceylon, and as such, a study of the chemical composition of the local paddies, rices and milling products would not be without interest and value. It would also afford data for comparison with that of other paddy growing countries. A search of the literature revealed a surprising lack of definite data on the analyses of Ceylon paddies and rices, though undoubtedly several of these must have been made. To those who might question the utility of such analytical data it may be replied that, though admittedly, the nutritive value of a sample of rice does not depend solely on its chemical composition but on the digestive capacity of the individual consumer, yet previous workers have shown that, other things being equal, the value of a sample of rice is almost directly proportional to its phosphoric acid and albuminoid or protein contents. It is a well known fact that the deficiency disease 'beri-beri' is to a great extent brought about by the consumption of highly polished rice, which in the process of polishing, has been deprived of its useful vitamins and as analysis reveals, a great proportion of its phosphoric acid, protein and fat.

It was therefore thought desirable that a systematic chemical study of some of our widely-grown and more characteristic paddies and rices, and of the effects of parboiling, pounding,

husking and polishing on their composition, should be made. Both pure line and ordinary mixed varieties were analysed. The analytical work included determinations of both organic and mineral constituents of the paddies and milling products, because of the importance of minerals in the diet of human beings and animals, and was carried out by Mr. Kandiah. The investigation was planned in co-operation with the Economic Botanist who supplied the pure-line paddies and undertook the husking and polishing by the method carried out in Ceylon villages, of both raw and parboiled rices. He will be contributing a separate paper on the botanical characteristics and milling properties of these rices, and also details of the village pounding process. Samples were also obtained through the kindness of the Manager, Sravasti Estate Rice Mills, Anuradhapura, of paddy and rice products at different stages of milling.

Experimental.

In all no less than 35 samples of paddies, rices and milling products were analysed, as detailed below.

Paddies.—Pure line *a8* (*Podiwi*), from the Economic Botanist.

Pure line B 11 (*Mawi*), from the Economic Botanist.

Murungan, from Sravasti Estate, Anuradhapura.
Hill Paddy (*Elwi*), from Ratnapura. ... 4

Rices.—(a) Husked by hand. ... 4

(b) Raw pounded by the village method. *a8*, B11, *Murungan*, Hill Paddy. ... 4

(c) Parboiled and pounded by the village method. *a8*, B11, *Murungan*, Hill Paddy, H.K. 13 (*Hinati*) and village *Hatiel*. ... 6

(d) Machine milled and polished.

(i) Ceylon—*Murungan* before polishing, from Anuradhapura.
Ceylon—*Murungan* after polishing, from Anuradhapura. ... 2

(ii) Foreign—*Muttu Samba*
Milchard. ... 2

Bran.—From raw and parboiled paddy.
a8, B11, *Murungan* and Hill Paddy ... 9

Husk.—From raw and parboiled paddy.
a8 and B11. ... 4

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From the detailed statement above it will be observed that the data obtained will afford some idea as to the differences in chemical composition (a) between pure-line paddies and paddy products and those of the ordinary cultivated varieties, (b) dry land and irrigated paddies and paddy products (c) as a result of husking, parboiling, and polishing paddies. Reference will be made whenever possible to the results of analyses of the rices, paddies, etc., of other rice-producing countries.

Analyses and Methods.—In each sample determinations were made of the moisture, nitrogen, protein or albuminoid, fat. fibre and ash contents by the ordinary analytical methods. The carbohydrates were obtained by difference. The ash was analysed for phosphoric acid and lime, these being regarded as the more important of the mineral constituents.

Results.—In all the tables, the figures in italics give the composition of the rices, etc., when calculated on dry matter at 100°C.

Table I.

Composition of Ceylon Paddies.

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	12·16	6·43	1·94	9·35	64·43	5·69	1·03	·600	·086
		7·32	**2·21**	**10·64**	**73·35**	**6·48**	**1·17**	**·680**	**·098**
B11 (*Mawi*) ...	12·27	6·60	1·89	11·52	61·78	5·94	1·06	·629	·087
		7·52	**2·15**	**13·13**	**70·43**	**6·77**	**1·20**	**·716**	**·099**
Murungan ...	11·95	6·31	1·84	10·65	63·35	5·90	1·01	·591	·073
		7·17	**2·09**	**12·11**	**71·93**	**6·70**	**1·15**	**·671**	**·083**
Hill Paddy (*Elwi*) ...	11·67	7·00	1·98	10·02	65·80	3·53	1·07	·353	·066
		7·59	**2·24**	**11·34**	**74·85**	**3·98**	**1·21**	**·406**	**·074**
Average ...	12·01	6·69	1·91	10·40	63·84	5·26	1·04	·544	·078
		7·40	**2·17**	**11·80**	**72·64**	**5·98**	**1·18**	**·618**	**·089**
Indian varieties (1) ...	12·67	6·11	2·09	8·29	64·82	6·02	—	—	—
		6·99	**2·39**	**9·51**	**74·22**	**6·89**	—	—	—
König (2) ...	9·6	5·9	1·8	5·8	72·7	4·2	—	—	—
		6·25	**1·99**	**6·42**	**80·42**	**4·65**	—	—	—
Burmese (4) ...	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	**·92**	**·54**	**·030**

It would be observed, although it is obviously impossible to generalize from a single analysis, that the sample of hill paddy is richer on the whole in organic constituents but poorer in minerals chiefly phosphoric acid than the irrigated paddies. This is what had previously been observed by other workers, e.g., Kellner in Japan and referred to by Cochran (2). A further observation is that the samples of pure-line paddies appear to be richer in proteins, fats and minerals than the ordinary cultivated paddy varieties, e.g., *Murungan*. The average chemical composition of the Ceylon paddies is similar to that of the Indian paddies (1) and those analysed by König (2). They appear however to be richer in proteins and minerals than the other paddies.

Table II.

Composition of Ceylon Rices.

(Husked by Hand.)

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*)	...	11·51	9·33	2·77	·61	74·05	1·73	1·49	·85	·085
			10·54	**3·13**	**·69**	**83·66**	**1·98**	**1·69**	**·96**	**·096**
B11 (*Mawi*)	...	11·77	9·44	2·06	·69	74·33	1·71	1·51	·94	·062
			10·70	**2·34**	**·78**	**84·24**	**1·94**	**1·71**	**1·06**	**·070**
Murungan	...	12·05	8·38	2·37	·83	75·09	1·28	1·34	·67	·055
			9·53	**2·70**	**·94**	**85·37**	**1·46**	**1·52**	**·76**	**·063**
Hill Paddy (*Elwi*)	...	11·21	9·26	2·47	·47	75·69	·90	1·48	·39	·052
			10·43	**2·78**	**·53**	**85·25**	**1·01**	**1·67**	**·44**	**·058**
Average	...	11·64	9·10	2·42	·65	74·79	1·41	1·46	·71	·064
			10·30	**2·74**	**·73**	**84·63**	**1·59**	**1·65**	**·81**	**·071**

The samples were obtained by husking each grain of paddy separately by hand. An examination of the figures of Table II. would show that next to carbohydrate, the rices are richest in proteins or flesh formers. Here again it will be observed that while the sample of hill paddy is just as rich in protein and fat as the irrigated paddies, it is poorer in minerals, chiefly phosphoric acid. The pure-line paddies a8 and B11 are also seen to be richer in protein and minerals than the ordinary cultivated paddy-*Murungan*, possibly because a8 and B11 are long-aged paddies and *Murungan* a short-aged paddy. With regard to the ash composition it will be noted that phosphoric acid is the chief constituent, amounting to about half the ash. Lime amounts only to about one-twentieth of the ash.

In Table III. is shown the average composition of the "husked" rices of other rice-growing countries. By "husked" is here meant as stated by Sen (3), rice "in the bran."

Table III.

Composition of Husked Rices.

(As Recorded by Previous Workers.)

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Phosphoric Acid.	Lime.	Authority.
Indian (Bihar)	...	(11·95)	**8·50**	**2·68**	**·86**	**86·14**	**1·82**	**·80**	—	Sen (3)
Burma Red Ngasein	...	(13·97)	**8·07**	**2·57**	**·84**	**86·89**	**1·63**	**·76**	**·028**	Warth and Darabsett (4)
Burma Byat	...	(12·31)	**7·85**	**2·78**	**·31**	**86·89**	**2·17**	**·78**	**·024**	ditto
Japan Mino Superior	...	(13·42)	**9·40**	**3·14**	**1·39**	**84·55**	**1·52**	—	—	Kellner (3)
Japan Echiu Medium	...	(13·65)	**7·98**	**2·43**	**1·83**	**86·72**	**1·04**	—	—	ditto
Hawii	...	(13·79)	**8·28**	**2·47**	**3·18**	**84·53**	**1·54**	—	—	Krauss (3)
* Ceylon (Hand-husked)	...	(11·64)	**10·30**	**2·74**	**·73**	**84·63**	**1·59**	**·81**	**·071**	

* Included for comparison.

It is obvious that these figures would only be strictly comparable if the method of "husking" adopted has been the same in all countries, but this is hardly possible. The Ceylon samples were hand-husked, the Indian varieties husked by gently rubbing them against two smooth planks of wood. The figures for Burmese husked rices are those of "loonzein" or skinned rice. No details are available regarding the method of husking of the Japanese or Hawiaan rices. It is therefore clear that as the husking processes are different, the analytical composition of the rices even of identical samples are bound to vary, being dependent on the amount of "skin" left on the grain after the husking.

A glance at Table III. would show that Ceylon rices compare favourably in chemical composition with those of other countries. The figures for protein are higher, but this is probably due to the fact that no loss of the "skin" took place in the husking of these paddies by hand. Ceylon rices approximate nearest to the Indian rices in composition. In fats and minerals they are about the average, but Ceylon rices seem to be somewhat richer in lime than the Burmese rices.

Changes in Chemical Composition due to Pounding, Husking and Polishing Rices by the Ceylon Village Method.—Samples of the paddies already referred to were subjected to husking and polishing by the Ceylon village method, viz: pounding, and the samples of raw rices obtained thereby, analysed.

A description of the method will be given by the Economic Botanist.

Table IV.

Composition of Ceylon Raw Rices.

(Pounded and Polished by the Village Method.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	12.27	5.89	1·18	·26	79·08	1·32	·94	·55	·059
		6·72	**1·34**	**·30**	**90·12**	**1·52**	**1·07**	**·63**	**·067**
B11 (*Mawi*) ...	12·08	8·64	·97	·22	77·46	·85	1·38	·46	·026
		9·82	**1·11**	**·25**	**87·85**	**·97**	**1·57**	**·52**	**·030**
Murungan ...	12·52	7·63	·80	·47	77 48	1·10	1·22	·45	·048
		8·72	**·92**	**·54**	**88·57**	**1·25**	**1·39**	**·51**	**·055**
Hill Paddy (*Elwi*) ...	11·95	8·39	1 04	·38	77·53	·71	1·34	·27	·041
		9·53	**1·18**	**43**	**88·05**	**·81**	**1·52**	**·30**	**·047**
Average ...	12·21	7·64	1·00	·33	77·90	1·00	1·22	·43	·043
		8·70	**1 14**	**·38**	**88·65**	**1·14**	**1·39**	**·50**	**·050**

A comparison of these figures with those of Table II. would show that husking and polishing of rices by the village method has resulted in a decrease in all their chemical constituents except carbohydrate, the decrease in fat, woody fibre, and phosphoric acid being to the extent of about half the original content. This is due to the "skin" and outer layer of the rice grain, the so-called

"aleurone" layer, which contains the more valuable nutritive constituents of the paddy grain, having been removed to a great extent in the husking process. The greatest loss of portein is observed in the case of a8, and is due probably to the ease with which its "skin" is removed while husking. These results bear out the previous work of Sen (3). The Indian polished rices were husked in an "okhri" the indigenous wooden mortar and pestle, the operation being continued till much of the coloured "skin" was removed. Compared with these, Ceylon rices are much the same in composition but appear to be somewhat higher in protein and minerals. The figures for the fat and protein contents of the samples of local raw rices polished by the village method are higher than those of the Burmese and Hawiaan rices but lower than those of the Japanese superior rices. The Burmese rices were however mill-polished and the reason for the significant differences in analytical composition between these and the Ceylon varieties, in favour of the latter, is therefore apparent. On referring to Table VII. it will be noted that mill-polished Ceylon *Murungan* rice has about the same chemical composition as the Burmese polished rices.

Table V.

Composition of Polished Rices.

(As Recorded by Previous Workers.)

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Authority.
Indian (Bihar)	...		8·14	1·09	·22	89·66	·89	Sen
Indian varieties	...	(12·8)	8·38	·69	·46	89·78	·69	Church
Burma white Ngasein	...	(11·48)	7·84	·61	·18	90·82	·55	Warth and Darabsett
Burma Byat	...	(12·5)	7·13	·56	·17	91·61	·53	ditto
Japan Superior	...	(15·21)	8·25	1·46	·56	89·02	·71	Kellner
Japan Medium	...	(15·27)	6·69	0·95	·46	91·35	·65	ditto
Hawii	...	(14·10)	7·89	·54	1·54	89·47	·56	Krauss
* Ceylon (Hand-polished)	...	(12·21)	8·70	1·14	·38	88·65	1·14	

*Included for comparison.

The Effect of Parboiling on the Chemical Composition of Rices.—In Table VI. below is given the analytical figures of Ceylon pure-line rices a8, B11 and *Hinati*, hill paddy, and ordinary cultivated *Murungan* and village *Hatiel*, parboiled and pounded by the village method. It will be noted that except in the fat content which falls somewhat, there is on the whole no appreciable change in chemical composition as a result of parboiling rices. But as the Economic Botanist will show, and as is commonly known (7) parboiling results in a higher percentage of whole rice being obtained, i.e., milling losses are greatly reduced. As regards individual analyses, it will be noted that the protein content of H.K. 13 (*Hinati*) is the highest and of a8 *Podiwi*, lowest of all the varieties analysed.

Table VI.

Composition of Ceylon Parboiled Rices.

(Pounded and Polished by the Village Method.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	12·72	5·81	·85	·26	81·22	1·29	0·93	·55	·046
		6·66	**·97**	**·30**	**90·60**	**1·47**	**1·06**	**·63**	**·053**
B11 (*Mawi*) ...	12·62	8·57	·76	·23	76·90	·92	1·37	·42	·030
		9·81	**·87**	**·26**	**88·01**	**1·05**	**1·58**	**·48**	**·034**
Murungan ...	14·74	6·88	·47	·39	76·33	1·19	1·10	·37	·041
		8·07	**·55**	**·46**	**89·53**	**1·39**	**1·29**	**·43**	**·046**
Hill Paddy (*Elwi*) ...	14·82	7·68	·84	·38	75·58	·70	1·23	·27	·042
		9·02	**·99**	**·45**	**88·72**	**·82**	**1·44**	**·32**	**·054**
Hatiel ...	12·89	6·68	·72	·36	78·49	·86	1·07	·36	·033
		7·67	**·83**	**·42**	**90·09**	**·99**	**1·23**	**·42**	**·038**
H. K. 13 (*Hinati*) ...	11·86	9·00	·75	·36	77·31	·90	1·44	·43	·041
		10·19	**·85**	**·41**	**87·53**	**1·02**	**1·63**	**·49**	**·046**
Average ...	13·24	7·44	·73	·33	77·64	·98	1·19	·40	·039
		8·57	**·84**	**·38**	**89·08**	**1·12**	**1·37**	**·46**	**·045**

The Effect of Machine-Milling and Polishing on the Chemical Composition of Rices.—In Table VII. below is shown the composition of Ceylon and foreign machine-polished parboiled rices.

Table VII.

Composition of Ceylon Parboiled Rices.

(Pounded and Polished by Machine.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
CEYLON:									
Murungan rice before poinshing ...	12·89	7·38	·78	·54	76·70	1·71	1·18	·48	·047
		8·48	**·90**	**·63**	**88·03**	**1·96**	**1·36**	**·55**	**·054**
Murungan rice after poinshing ...	13·24	6·31	·38	·33	78·14	1·60	1·01	·37	·041
		7·27	**·44**	**·38**	**90·07**	**1·84**	**1·16**	**·43**	**·047**
FOREIGN:									
Muttu Samba ...	11·48	6·28	·42	·23	80·85	·74	1·00	·33	·026
		7·10	**·48**	**·27**	**91·32**	**·83**	**1·13**	**·37**	**·029**
Milchard ...	11·56	5·97	·80	·25	80·75	·66	·96	·32	·024
		6·75	**·90**	**·29**	**91·30**	**76**	**1·08**	**·36**	**·027**

The samples of Ceylon machine-polished rice were prepared from *Murungan* paddy from Sravasti Estate, Anuradhapura. Analyses were made of the rice before polishing and after polishing. It will be observed that the composition of the *Murungan* rice before polishing is not very different to that of the *Murungan* raw rice pounded by the village method. But on polishing, the rice loses the greater part of its fat, this being reduced to less than half its previous value. Its protein, ash and phosphoric acid contents also decrease. Compared with the hand-husked *Murungan* rice, the phosphoric acid content of the machine

sample is only about half. Machine-polishing of Ceylon rices brings its composition more or less into line with those of the Indian and Burmese polished rices largely imported into Ceylon, e.g., *Muttusamba* and *Milchard*. The Ceylon polished *Murungan* is however slightly higher in protein, phosphoric acid and lime but lower in fat than these latter. In this connection it has to be pointed out that the sample of *Milchard*, a lower grade and cheaper rice than *Muttusamba*, has nearly twice the amount of fat. This is probably a single instance of what has been demonstrated by some workers in Japan, e.g., Sawamura (3) "that inferior rice is likely to be rich in fatty matters and ash." The result of polishing is to reduce the fat, protein, phosphoric acid and lime contents of a sample of rice considerably, and especially the fat and phosphoric acid. By the village method of preparation of rice it would appear that less fat and phosphoric acid would be lost to the grain than by machine-polishing. The more perfect the polish, the less fat and phosphoric acid the rice contains, but the higher its market price. This is an observation made by several previous workers, viz: Hooper (6) and Kellner and Nagakoa (3). As a lack of phosphoric acid has been found to be a pre-disposing cause of beri-beri, it is surprising why polished rices are in greater demand and fetch higher prices than the less polished rices. It is probably because polished rice cooks better besides being cleaner and better looking.

It would be interesting at this stage to compare the chemical composition of rice with that of the more important grains, pulses and legumes commonly used as food. In Table VIII. are shown the compositions of these foodstuffs as quoted chiefly by Wood (5).

Table VIII.

Composition of Foodstuffs.

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.
Wheat (5)	...	13·4	12·1	1·9	1·9	69·0	1·7
Wheat flour	...	13·3	10·2	·9	0·3	74·8	0·5
Oats	...	13·3	10·3	4·8	10·3	58·2	3·1
Maize	...	13·0	9·9	4·4	2·2	69·2	1·3
Millet	...	12·5	10·6	3·9	8·1	61·1	3·8
Gram	...	11·0	23·4	1·1	5·1	54·3	5·1
Dhal (1)	...	10·9	16·6	1·0	4·8	62·9	3·7
Rice husked	...	11·64	9·10	2·4	·65	74·9	1·4
Rice hand-polished	...	12·2	7·64	1·0	·33	78·0	1·2
Rice Machine-polished	...	13·24	6·3	·38	·33	78·2	1·6

Compared with other foodstuffs it will be noted that polished rice has very much less protein and fat, but considerably more carbohydrate, and that it is nearest to wheat flour in composition. It has therefore a wide nutritive ratio. Unpolished rice however

approaches fairly closely wheat in chemical composition, though it is richer in carbohydrate content. Rice pounded by the village method much more nearly approximates the other grains in composition than polished rice. It will also be noted that legumes like dhal, gram, etc., are much richer in protein than cereals and have consequently a narrow nutritive ratio. A diet comprised of polished rice and legume or other albuminoid substances will therefore form a much more balanced ration than rice alone.

Brans.

Table IX.

Composition of Brans.

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
From Raw Rice.									
a8 ...	11·22	9·93	10·85	13·98	40·42	13·6	1·59	2·97	·235
		11·17	**12·23**	**15·75**	**45·53**	**15·32**	**1·80**	**3·34**	**·265**
B11 ...	11·79	11·31	9·32	14·32	43·09	10·17	1·81	2·97	·162
		12·82	**10·58**	**16·24**	**48·83**	**11·53**	**2·07**	**3·36**	**·184**
Murungan ...	16·38	10·44	7·48	14·43	38·06	13·21	1·67	3·70	·426
		12·47	**8·93**	**17·26**	**45·55**	**15·79**	**2·00**	**4·43**	**·510**
Hill Paddy ...	10·64	11·01	12·81	13·46	43·32	8·76	1·76	1·99	·296
		12·31	**14·34**	**15·06**	**48·49**	**9·80**	**1·98**	**2·23**	**·331**
Average ...	12·51	13·17	10·12	14·05	38·72	11·44	1·71	2·93	·280
		12·19	**11·52**	**16·07**	**47·10**	**13·11**	**1·95**	**3·34**	**·323**
Burmese Meal (4) ...	8·21	5·72	8·31	25·18	34·25	18·34	—	—	—
		6·23	**9·04**	**27·44**	**37·31**	**19·98**	—	—	—
From Parboiled Rice.									
a8 ...	11·13	9·29	12·17	13·90	34·63	18·90	1·49	3·42	·440
		10·46	**13·68**	**15·65**	**38·98**	**21·23**	**1·68**	**3·85**	**·493**
B11 ...	11·70	10·81	14·30	14·78	34·11	14·30	1·74	4·08	·220
		12·25	**16·18**	**16·75**	**38·75**	**16·07**	**1·97**	**4·61**	**·249**
Murungan ...	13·22	8·44	7·66	15·32	38·46	16·90	1·35	4·62	·418
		9·73	**8·83**	**17·62**	**44·67**	**19·15**	**1·55**	**5·33**	**·481**
Hill Paddy ...	10·19	11·49	12·97	14·01	41·42	9·92	1·84	2·03	·380
		12·79	**14·44**	**15·60**	**46·13**	**11·04**	**2·08**	**2·26**	**·422**
Average ...	11·56	10·01	11·78	14·50	37·15	15·00	1·60	3·58	·362
		11·31	**13·28**	**16·40**	**42·13**	**16·87**	**1·81**	**4·01**	**·411**
Murungan (Machine made) ...	8·64	11·81	7·36	16·82	19·94	35·43	1·89	1·31	·441
		12·93	**8·06**	**18·41**	**21·87**	**38·73**	**2·06**	**1·45**	**·481**

A glance at Table IX would show that the brans or the residues obtained after the second pounding by the village method, are much richer in fat, phosphoric acid and lime, and to a lesser extent in proteins than the corresponding rices. This is due as already pointed out to the concentration of the fats, minerals and to a lesser extent proteins in the "skin" and "aleurone" layer of the rice grain. The fibre and ash contents of the brans are much higher but the carbohydrate contents much lower than that of the corresponding rices. The amounts of bran obtained are however small and it may be thought that the actual amounts of nutritive constituents removed by husking would not be very great. This is not so, as the following Table in the case of *Murungan* paddy, would show.

Table X.

	Protein. lb.	Phosphoric Acid. lb.	Fat. lb.
100 lb. *Murungan* paddy containing ...	6·31	·59	1·84
Gave 73 lb. Parboiled rice containing (see Table VI.) ...	5·02	·27	·34
68·4 lb. Raw rice containing (see Table II.) ...	5·21	·29	·53
Therefore bran and husk from Parboiled rice contained ...	1·29	·32	1·50
Therefore bran and husk from Raw rice contained ...	1·10	·30	1·29
Mean ...	1·2	31	1·4
Percentages of nutritive constituents in bran and husk on those in paddy ...	19·0	52·5	76·0

It would thus appear that over three-fourths of the fat. half the phosphoric acid and one-fifth of the protein content of the paddy is lost in the bran and husk. The greater part of this is found in the bran. This bears out what has been found by Warth and Darabsett (4).

To turn again to Table IX, it would be seen that the effect of parboiling rices is to increase the fat content of the bran as it decreases that of the rice. The mineral content is also increased. The sample of bran obtained from the machine polishing of *Murungan* paddy is characterized by its very high ash content due probably to contamination with sand. The samples of bran from Ceylon paddies compare very favourably with those of Burma (4).

Husk.

The husk is the residue obtained from the first pounding of the paddies by the Ceylon village method.

In Table XI below is shown the composition of husks obtained from raw and parboiled paddies. The samples obtained contained varying proportions of bran and broken rice grains and hence are not typical. High results are obtained for proteins and minerals as compared with the figures of Warth in Burma, (4) but they are similar to those of Wolff as quoted by Cochran (2). Parboiling appears to increase the fat and phosphoric content of the husk, but otherwise there is little effect on its chemical composition.

Table XI.

Composition of Husk.

Percentages.

From Raw Rice.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 ...	11·03	3·37	1·28	39·01	25·56	19·75	54	495	·257
		3·78	**1·44**	**43·80**	**28·78**	**22·20**	**·61**	**·556**	**·307**
B11 ...	11·67	4·43	1·24	41·44	26·11	15·11	·71	·51	—
		5·01	**1·41**	**46·39**	**29·58**	**17·11**	**·80**	**·578**	—
Average ...	11·35	3·90	1·26	40·22	25·83	17·43	·62	·502	—
		4·39	**1·42**	**45·34**	**29·18**	**19·65**	**·70**	**·567**	—
Wolff (2) ...	9·7	3·4	1·4	42·8	27·0	15·7	—	—	—
		3·72	**1·53**	**46·87**	**29·51**	**17·20**	—	—	—
Burmese (4) ...		—	—	—	—	—	·03	·041	—

From Parboiled Rice.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 ...	10·97	3·63	1·39	39·42	24·27	20·32	·58	·584	·234
		4·07	**1·56**	**44·26**	**27·29**	**22·82**	**·65**	**·654**	**·267**
B11 ...	11·34	4·28	2·08	39·67	25·13	17·50	·69	·780	—
		4·82	**2·34**	**44·72**	**28·39**	**19·73**	**·78**	**·883**	—
Average ...	11·15	3·95	1·73	39·54	24·70	18·91	·63	·682	—
		4·44	**1·95**	**44·49**	**27·84**	**21·27**	**·71**	**·768**	—

Conclusions.

Chemical analyses were made of samples of typical Ceylon paddies, rices and milling products, and the changes in chemical composition of the grain as a result of parboiling, pounding and polishing by the Ceylon village method, and machine-milling and polishing, studied.

The following conclusions have been drawn:—

(1) Ceylon paddies are on the whole similar in composition to the paddies of India and other paddy growing countries. They appear however to be richer in proteins and minerals than the latter. Dry land or Hill paddy as reported by previous workers, is found to be richer in organic constituents but poorer in minerals than irrigated paddies. The pure-line paddies analysed were richer in nutritive constituents than the mixed varieties.

(2) The same remarks as above apply to the hand-husked rices. The high protein content of Ceylon hand-husked rices as compared with those of other countries is very probably due to the method of husking. Phosphoric acid is the chief inorganic constituent of the samples analysed and amounts to just over half the ash content.

(3) The pounding and polishing of rices result in a marked decrease in their fat, phosphoric acid, fibre and to a smaller extent protein contents. It would therefore appear that the "skin" and surface or "aleurone" layer of the rice grain contain the more valuable nutritive constituents of the grain. Machine polishing of rices results in greater losses of fat and phosphoric acid than by the village method of pounding.

(4) Parboiling affects inappreciably the chemical composition of rices except for the fat content which falls slightly.

(5) Bran or the residue after the second pounding of paddies contains large proportions of the fat, protein and phosphoric acid of the latter. More than half the phosphoric acid, three-fourths the fat and one-fifth the protein of *Murungan* paddy were found in the bran. Higher percentages of fat and ash are found in the bran of parboiled than of raw rices.

(6) The chemical composition of polished rice is nearest to that of wheat flour. Rice has much less protein and fat and considerably more carbohydrate than other foodstuffs. A diet of rice and legumes is a well-balanced one.

(7) The samples of husk analysed were not typical, but the analytical data are similar to those obtained by Wolff (2). The ash content is very high.

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Rice Outturns of Paddies Husked for the Agricultural Chemist.

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CERTAIN of the paddies dealt with by Messrs. Joachim and Kandiah in their paper " The Chemical Composition of Some Ceylon Paddies, Rices and Milling Products " which appears in this issue of the *Tropical Agriculturist*, were husked under the writer's supervision. Some of the paddies, moreover, were pure-line selections of Ceylon varieties extracted by the Division of Economic Botany. It was thought, therefore, that a short account of these paddies, their rice outturns and methods of husking would appropriately follow the paper mentioned above.

The paddies in question are the three cultivators' varieties *Hatiel*, *Murungan* and *Elwi* (Hill Paddy) and the three pure-line selections a-8, B-11 and Hk-13. Table I. gives a brief description of the paddies.

Hill Paddy is grown under dry conditions as one of the crops in the 'Shifting' or *Chena* system of cultivation where jungle is felled and burned *in situ* prior to taking two or three crops before moving on to a fresh patch of jungle. *Chena* is the equivalent of the *Taungya* cultivation of Burma. Hill Paddy almost invariably contains seed of *Amu* (Paspalum scrobiculatum) and the presence of this grain has probably been instrumental in raising slightly the rice outturns. The figures for length and breadth where available have been supplied by Mr. Abeyesundera, Assistant in Economic Botany, who is at present working on the measurements of the more common Ceylon paddies.

Table I.
Description of Some Ceylon Paddies.

Variety or Selection	Extracted from Variety	Approximate Age when broadcasted Sowing to Maturity *Months*	Mean Length of unhusked grain in m.m.	Standard Error of Mean	Mean Breadth of unhusked grain in m.m.	Standard Error of Mean.	Remarks.
Hatiel	—	6-6½	7·955	0·042	3·272	0·02	Grown in the Central Province.
Murungan	—	3	8·06*	0·0256	3·505	0·0169	Grown in North-Central Province & Mannar District.
Hill Paddy	—	4	—	—	—	-	Grown under dry conditions as a *Chena* crop.
a-8	*Podiwi*	6	6·022	0·009	3·01	0·0073	A small grained table rice similar to *Muttusamba.*
B-11	*Mawi*	6	8·34	0·039	3·485	0·0135	Grown in the Central Province.
Hk-13	*Hinati*	4	7·87	0·047	3·035	0·0211	A short-aged paddy grown during the S.W. Monsoon.

*The measurements against Murungan are taken from the pure-line extraction of Murungan Mb-14.

The different paddies were husked both raw and after being parboiled, both the husking and the parboiling being carried out according to the Ceylon village method. The method of husking both raw and parboiled grains is the same and consists of the primitive method of pounding in a mortar. Plate I. shows the pestle and mortar and also the winnowing tray (*Kulla*) used in separating out the husk and bran. The pestle (*Molgaha*) is frequently shod with an iron ring. The mortar is known as a *Vangediya*. The first pounding removes the husk, the second some of the *testa* (bran) and a third pounding gives a slight polishing by removing most, but not by any means all, of the remaining testa.

Parboiling as practised in rice mills has been described by Charlton.* The village method of parboiling is extremely simple. The paddy is placed in a receptacle capable of being heated over the fire. Generally a copper pot (*Thamba heliya*) is used but earthenware pots or even kerosene oil tins may be employed. Usually not more than two bushels of paddy are dealt with at one time. The paddy is covered with water to a level of about 2 in. above the grains. The receptacle is then placed over a fire and heated until after boiling for some time the glumes commence to split open. The paddy is then spread out on mats to dry; this takes from one to two days according to the humidity and to whether the mats are put in the sun or in the shade. Drying in the shade is said to be preferred. The paddy is ready to pound when the grains have become hard. This is tested by biting with the teeth.

*Charlton, J.—The prevention of nuisances caused by the parboiling of paddy. *Agric. Res. Inst. Pusa.* Bull. No. 146, 1923.

PLATE I.

The Village Method of Husking Paddy.

Photo taken at Laboratory of the Economic Botanist, Peradeniya.

Of the objects of parboiling Charlton (*op. cit.*) says: "It is stated by people who eat this variety that parboiled rice is more sustaining than white rice. Coringee coolies who are large consumers state that after a meal of parboiled rice they can work throughout a whole shift of eight hours without a further meal. If white rice were substituted they could not do this.

"Parboiled rice is perferred on account of its taste. It is stated that when cooked it remains sweet for a longer period than white rice, and if subsequently warmed up, the flavour is less adversely affected than that of white rice similarly treated.

"Although parboiled rice has been partially cooked, it is not so easy to prepare for food as white rice.

"An advantage for parboiled rice is claimed inasmuch as it interferes less with digestive powers than white rice.

"It is certain that the milling losses are reduced by this process. Breakage is greatly diminished. Partly because of this reduced breakage, the profits to the miller are increased by parboiling."

There is no doubt as to the efficacy of parboiling in reducing breakage as reference to Table II. will show. The total outturn of rice from parboiled paddy is also larger than from raw paddy—part of the increase is explained by the additional water absorbed during parboiling. After parboiling there is much less difficulty—as would be expected—in removing the partly opened glumes from the rice. As to the superior keeping qualities of parboiled rice little experimental evidence is available. The Agricultural Chemist kindly carried out a test to see if the acidity of parboiled rice was less than that of raw rice 24 hours after cooking. He reports that there is slightly more acid in the raw rice, but that the total acidity is very small. After 24 hours there was no appreciable difference in the taste of the two kinds of rice. It is possible that the acid which develops is harmful and that a slight addition will affect digestion.

Table II.

Rice Outturns as Percentages by Weight.

Paddy	Hatiel		Murungan		Hill Paddy		a-8		B-11		Hk-13	
Method of Pounding	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled
Whole Rice ...	—	69·5	44·4	69·6	48·7	75·4	57·5	64·4	39·4	58·2	56·2	65·6
Broken Rice ...	—	2·6	24·0	3·4	23·7	3·7	10·3	7·5	17·5	10·1	13·2	9·4
Total ...	—	72·1	68·4	73·0	72·4	79·1	67·8	71·9	56·9	68·3	69·4	75·0

Parboiling is universal in Ceylon, raw rice being used only for preparing a dish known as *Kiri-bat* and for turning into rice flour. This may account for the fact that, contrary to Charlton's experience in Burma, the Ceylonese find parboiled rice easier to cook than raw rice.

Ten pounds of paddy were used in each test. It is not claimed that the respective amounts of whole and broken rice are

accurate although one woman carried out all the tests. The figures for broken rice represent, however, the percentages which would have been removed by a village woman. The whole rice portion invariably contained some broken grains. It is also extremely probable that the woman who did the pounding did not polish each sample equally, thus altering to some extent the percentage of broken rice, for the more the polishing the greater the breakage. While allowing, therefore, for a considerable human error it is yet possible to draw two definite conclusions:—

(1) Parboiling causes a greatly reduced breakage and therefore a larger percentage of whole rice.

(2) Parboiling raises slightly the total outturn of rice. About 1% only of this is due to added moisture as may be seen from Joachim and Kandiah's figures in Tables IV. and VI. (*op. cit.*).

The figures in Table II. give no opportunity of a direct comparison of the rice outturns of a cultivator's variety and a pure line selection of that variety. The figures in Table III. which give this opportunity, although the paddies did not form part of those chemically analysed, are included here as a matter of interest.

Table III.

Comparative Rice Outturns in Percentages from Village and Pure-line Paddy, Parboiled.

		Murungan by weight.	Mb-14 by weight.	Murungan by volume.	Mb-14 by volume.
Whole Rice	...	71·4	76·0	55·3	57·0
Broken Rice	...	4·1	1·5	3·0	1·3
Total	...	75·5	77·5	58·3	58·3

The weights and volumes in the above table were taken immediately after pounding. They would be reduced slightly if the rice were kept under very dry conditions. The Murungan paddy was kindly supplied by the Hon. Mr. W. A. de Silva, M.L.C. Mb-14 is an extraction from village Murungan. A cut bushel of each paddy was used. Murungan weighed 49·4 lb. and Mb-14, 48 lb. It will be seen that although the total outturn of the two paddies by volume is the same, yet the percentage of broken rice in the pure line paddy is less than half that of the Murungan. This is explained by the even size of the grains in the pure-line paddy.

So far as Ceylon is concerned the basis of selection in paddy is yield of grain per unit area. With a rice-milling industry in an embryonic condition selection on the basis of yield of rice per unit area is not yet necessary and explains why Mb-14 is not superior in total outturn to the mixed variety. The milling percentages of selections are now being studied and the final choice between equally high yielding strains will be determined by the milling outturns.

Paddy Notes (III).

a. The Germination of Rice Seeds in Ceylon.

b. The Effect of Attack by Paddy Moth and Paddy Weevil on the Germination of Rice Seeds.

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(a) The Germination of Rice Seeds in Ceylon.

GERMINATION tests with rice have been conducted at Peradeniya during the past two years and a certain amount of data of general interest has been obtained. The results of the tests have been fully described in a paper which, it is hoped, will appear shortly in the *Annals of the Royal Botanic Gardens, Peradeniya*, under the above title. This account summarises the results described in that paper.

The objects of the tests were (i) to determine the length of the resting period (the period after harvest during which rice seed will not germinate) in *Maha* (long-aged) and *Yala* (short-aged) paddies; (ii) to determine the effect of the local custom of smoking in curtailing that period and (iii) to determine the effect of the age of the seed on rapidity of germination. During the course of the investigation it was noticed that light-glumed seed germinated better and more rapidly than dark-glumed seed and tests were laid down to obtain evidence on this point.

It was necessary in the first place to determine a suitable method of conducting the tests. Mitra and Gangully* (1926) carried out tests on blotting paper placed over moist saw-dust, with another sheet of moist blotting paper placed over the seed.

*Mitra, S. K., and Gangully, P. M.—Rice seed-testing. *Agric. Jour., India*, XXI., VI., 1926. 421-428.

A somewhat similar method has been used in Burma. It was thought that in the, generally, moist climate of Peradeniya the use of saw-dust would encourage the growth of moulds which, in all the methods tried, develop in time on the seeds and reduce the germination percentage. Four different methods were therefore tested:—

(1) Porous dishes containing no standing water.

(2) Porous dishes with standing water, and, with both these methods, previously washing the seed in a one-in-a thousand solution of mercuric chloride to retard the development of moulds.

(3) Porous dishes containing standing water but with the seeds not washed with a mercuric chloride solution, and

(4) Seeds placed on moist sterilized sand.

The porous dishes used in methods (1), (2) and (3) were 2 $\frac{3}{8}$ in. square, about $\frac{1}{4}$ in. thick and with a $\frac{1}{4}$ in. rim which kept the seeds on the dish. Such dishes may be seen advertised in the catalogues of makers of scientific instruments. The porous dishes were placed in zinc trays holding from 24 to 30 dishes and which were fitted with lids which could be closed at night to prevent damage by mice and rats. Each dish held 100 seeds. About $\frac{1}{4}$ in. of water stood in the trays to keep the dishes moist. It was found that porous dishes with no standing water, and with the seeds washed with mercuric chloride gave the best result—the standard error of tests with 200 seeds being 1·14%. The use of mercuric chloride for washing seeds prior to testing is to be recommended. The duration of the tests was ten days. Villagers' seed paddy is usually completely germinated within from five to eight days but this paddy is kept in bulk and under pressure during the germination. It was considered that ten days in dishes would approximate to seven or eight days in bulk and under pressure.

The Viability of Paddy Seed immediately after Harvest.

There are districts in Ceylon in which the same variety of seed is sown both for *Yala* and *Maha* and where the harvest of one crop is used as the seed of the next after being in storage for but a few weeks. In village practice such seed is often "smoked" (by being placed over the cooking fire) in an attempt to quicken the germinating power of the seed. Tests were laid down with *Maha* and *Yala* paddies to determine the duration of the resting period in Ceylon and to find out the effect of smoking on curtailing

that period. From the evidence of the tests it was concluded that

(i) The resting period in *Maha* (long-aged) paddies is about $2\frac{1}{2}$ months whereas with *Yala* (short-aged) paddies if harvested when dead ripe, there is very little, if any, resting period. It is possible that certain *Yala* paddies do have a short resting period.

(ii) Smoking increases the germination of both *Maha* and *Yala* paddies. In the second month after harvest smoking increases the germination of *Maha* paddies from 10% to 30%. By the middle of the third month the effects of smoking are almost negligible. *Yala* paddies so quickly attain their maximum viability that smoking is necessary only if the seed is to be sown immediately after harvest.

Age of Seed and Rapidity of Germination.

Maha and *Yala* seed of varying ages was tested to determine the effect of age on the rapidity of germination. The following conclusions were drawn:—

(1) Comparatively new *Yala* seed almost completes its germination by the sixth day; with similarly aged *Maha* seed germination is almost completed by the eighth day. Over 85% of four months old *Yala* seed has germinated by the fifth day and 70% of four months old *Maha* seed by the sixth day. If seeds were germinated in bulk and under pressure these amounts would probably be increased.

(2) Old seed commences to germinate later, and continues to germinate longer, than new seed. Under village conditions much of this seed would rot before germination was half over.

The Effect of Glume Colour on Germination.

From the tests laid down to obtain evidence on this point it was concluded:—

(1) In general, light-glumed seed germinates sooner and completes its germination in less time than dark-glumed seed.

(2) The total germination of dark-glumed seed is less than that of light-glumed seed.

It is possible, however, that there is a tendency to harvest dark-glumed paddies on the immature side owing to the greater difficulty with such paddies of judging maturity by observation. This may be a partial explanation of the results obtained in these tests and it is hoped to carry out further investigations on this point.

(b) The Effect of Attack by Paddy Moth and Paddy Weevil on the Germination of Rice Seeds.

Paddy seed stored in gunny bags or in anything except insect-proof receptacles is, in Ceylon, liable to become infested with Paddy Moths (*Sitotroga cereallela*) and Paddy Weevils (*Calandra oryzae*). Quite frequently paddy seed stored in insect-proof bins is found to be infested with moth indicating that infestation may occur either in the field or in the stack. The caterpillars (larvae) of the moths and both the adults and grubs (larvae) of the weevils feed in and on the rice grain and it is only natural to assume that the ravages of these pests materially affect the germination of the seed either by destroying the germ itself or by consuming the most part of the endosperm. Experiments were started in 1927 at Anuradhapura to determine the amount of the damage caused to paddy seed stored in gunny bags. The first experiment was carried out with a *Maha* (long-aged) paddy threshed in April, 1927. On 18-5-27 the viability of the seed was 93%. A sample of the seed was stored in an insect-proof bin and was fumigated. The remainder was left in the gunny bag exposed to moth and weevil attack. Just before sowing time, on 22-8-27, a germination test of the sample stored in the bin gave 90% viability. Two samples were taken from the gunny bag, one, from the outside and one a representative sample of the whole bag. The germination percentages were respectively 91·5% and 81·5%. The greater viability of the sample taken from the outside of the bag than of the seed stored in the insect-proof bin is curious but is probably due to the normal errors of sampling. The 10% difference between the germination of the representative sample and the sample from the outside of the bag indicates that the most damage occurs away from the light. The figures show that attack by moth and weevil has, in the course of just over three months, reduced the germination of the seed by 8·5% the normal germination at the time of the second test being 90%.

The experiment was repeated with a *Yala* (short-aged) paddy harvested in August, 1927. This time two bags of seed were taken and the experiment conducted in duplicate. The two bags were labelled (a) and (b) and (a) had not received as much winnowing as (b). When tested on 27-9-27 (a) gave a germination percentage of 95·5 and (b) of 93. The sample which had had less winnowing gave a slightly higher germination percentage but as will be seen later, suffered more severely from attack. As before, the two bags were kept exposed to attack after previously placing samples of the two bags in an insect-proof bin and fumigating them. Germination tests were again carried out on

6-2-28 and the results will be found in Table I. This time samples were taken from the centre of the bags and representative samples from the whole of the bags. Taking samples from the centre of the bags offered another means of discovering where the attack was greatest.

Table I.

Germination percentages of Paddy Seed Exposed to and Protected from Insect Attack.

Sample	Test on 6·2·28				Test on 27·9·27
	Exposed to attack			Protected Stored in bins	
	Centre	Whole bag	Mean.		
Bag (a)	68·5	68·0	68·25	87·5	95·5
Bag (b)	71·0	76·5	73·75	85·5	93·0
Mean	69·75	72·25	71·0	86·5	94·25

The figures show that in a little over four months the germination of seed exposed to attack of moths and weevils was reduced by 23·25% whereas the normal reduction in seed protected from the pests was only 7·75%. The total reduction, therefore, due to the infestation is 23·25-7·75 or 15·50%. Again it will be noticed that the most damage occurs in the centre of the bag.

Damage by insect attack to paddy seed stored in gunny bags is thus shown to be appreciable. So far as the cultivator is concerned the damage is not so serious, as small quantities of seed may be stored in the kitchen whose smoke acts as a partial deterrent. Where, as at Paddy Seed Stations, large quantities of seed of different varieties have to be stored the problem is more difficult. If wooden or galvanized-iron receptacles are used they should be capable of being rendered air tight to allow of fumigation by carbon bisulphide. This fumigation should take place soon after the seed is placed in the receptacle and, if necessary, should be repeated. When seed is stored in gunny bags it would appear essential, if damage by insect attack is to be appreciably reduced, to make provision for one air-tight chamber or box where the whole of the seed paddy can be fumigated in successive lots at least once, and the first time immediately after threshing. If an initial fumigation can be given, periodic exposure in the sun should keep the damage within reasonable limits. The above remarks apply to those districts where the seed of the *Maha* crop is saved for the next *Maha* season and seed of the *Yala* crop for the next *Yala* season. In those districts where the seed from one crop is sown for the succeeding season the problem of storage does not arise.

It has been observed that napthaline in an enclosed receptacle exerts a definitely deterrent and a possibly toxic effect on paddy moth. Experiments are now in progress to ascertain if napthaline has any detrimental effect on the viability of the seed.

The Two Weevil Pests of Plantains.

(*Musa sapientum* L.)

Cosmopolites sordidus Germ.
and
Odoiporus longicollis Oliv.

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Introduction.

THE prevalence of the two plantain weevils, one attacking chiefly the rhizome and the other the stem of plantains or bananas, has been known in Ceylon for many years, but the damage wrought by these insects has been overshadowed more recently by that caused by the "Bunchy Top" disease. Although these two insect pests do not warrant the same serious consideration as the Bunchy Top disease, which is a serious menace to plantain cultivation, they must nevertheless be recognized as the most serious insect pests which the plantain grower has to combat. Great damage to the plantains, all varieties of which are equally susceptible to injury, is done by the grubs of these two insects which tunnel extensive galleries in the rhizomes (commonly called "bulbs" or "corms") and in the stems respectively. Owing to their destructive habits, both these insects have been declared "pests" under the Plant Protection Ordinance No. 10 of 1924, but no general campaign has been waged against them.

Hitherto very little work has been done in Ceylon on these two insects. Therefore as a preliminary to further investigation under Ceylon conditions their life histories have been worked out in the laboratory at Peradeniya and field observations made whenever opportunity permitted. The results of these observations supplemented by information gathered from work done in other countries (see references) are submitted in this article.

The two beetles, which may be found associated in the same plantain stool, belong to the family of weevils, or *Curculionidae*, the members of which are easily recognizable by reason of their distinctly prolonged snouts, or rostra, formed by the continuation of the foreparts of their heads. Of these two pests, the Root Weevil is considered to be the more serious.

The Root Weevil

(*Cosmopolites sordidus* Germ).

This destructive enemy of plantains has proved a formidable menace in some parts of the world, where the plantain, or banana, is cultivated on a much larger scale than in Ceylon. Fortunately, however, the conditions in Ceylon cannot be considered so serious as those in other countries. But the damage that this insect can inflict, unknown to most growers of plantains, invites co-operative action for its control.

Host Plants.

In Ceylon, as in almost all other countries where the pest is found, the Root Weevil appears to attack only plantains. In the Philippines, however, according to Cendaña (1), besides damaging plantains it is also a serious pest of Manila hemp (*Musa textilis* Nees.) which is an important industry there. Moznette (6) and Froggatt (3) mention it as having been reported to have damaged sugar-cane, but this seems rather doubtful.

Distribution.

General.—Though known to science for a little over a century (2), (4), the original home of this cosmopolitan insect is not known (5). It enjoys a wide geographical range and has been recorded a pest in almost every country where the plantain, or banana, is cultivated.

Local.—The weevil is fairly well established in the Island and is found in most of the plantain growing districts.

Description of Stages.

Adult (fig. 1).—A little less than 1/2 in. long and usually about 1/6 in. broad; chestnut-brown when freshly emerged, but gradually turning to dull black in a few days. Rostrum or snout about 1/8 in. long, slightly curved and slender, the distal end being provided with a pair of mandibles. Antennae, as in most weevils, geniculate or elbowed. Thorax marked with fine punctures. Wing covers, or elytra, bear distinct longitudinal furrows, or striae, and cover the abdomen except its last segment. No marked distinction between the sexes, except that the males are usually smaller than the females.

Egg (fig. 2).—About 1/15 in. long by about 1/30 in. broad, elongate-oval and creamy white.

Larva (figs. 3 and 4).—Newly hatched larva nearly 1/12 in. long, whitish except its head which is light brown. Full grown larva about 1/2 in. long and 1/3 in. broad, creamy white, legless, soft and fleshy, with a reddish-brown head; body wrinkled, with the middle portion much swollen; a few hairs on head, thorax and terminal segments of the body.

Pupa (fig. 5).—Almost 1/2 in. long and about 1/5 in. broad; naked and soft; at first creamy white, then turning to light yellow and finally to light reddish brown; the partially developed wings, rostrum and legs can be seen folded upon the ventral surface of the body.

Habits and Life History.

Weevils.—The weevils may be found in infested rhizomes in the surrounding soil or sheltering in decaying plant tissue or in the loose fibre surrounding the base of the stem. They shun light and are most active after dark. They crawl from place to place at night, and Cendaña (1) has observed that this insect will cover over 15 metres in a single night. They seldom fly except after dusk. The writer has not observed the insects on the wing, but Froggatt (3) and Urich (7) have definitely stated that the weevils do fly. The insects are sluggish and when disturbed they feign death by lying motionless for some time. They are long-lived. When supplied with food and kept under laboratory conditions they are said to have lived for more than two years (3). Under similar conditions the writer has kept them for about five months when the experiment had to be abandoned. In moist earth, without food, they were kept alive for about two months and Froggatt (3) has kept them alive for six months. Froggatt (3) has noticed that in dry soil they die in a few days, and similar observations were made here.

From observations made and reports available it appears that the Root Weevil is found throughout the year in Ceylon; this is also true of most other countries where the pest is found. As plantains are grown all through the year and repeatedly on the same land, a plentiful food supply is provided and several broods of weevils are produced during a year.

Eggs.—The weevils after emergence mate and in due course the females start laying eggs. They are generally laid at the base of the plantain stem just about ground level or in the rhizome, each deposited singly in a recess prepared by the female. The eggs are extremely difficult to detect not only on account of their minute size, but because the slits in which they are deposited are practically closed and also owing to their isolated occurrence. They are usually found either at or just above the base of the

stem; they may also be laid in the rhizome, where they are embedded, generally on the border of a larval gallery or in unaffected portions. Eggs may also be laid in stems, especially in stumps left standing after the bunches have been removed and in stems lying on the ground. Old bulbs also are favoured sites.

Larvae.—The eggs hatch in about a week (6-7½ days) and the minute grubs bore into the rhizome to feed. The young larvae from now onwards excavate tunnels, which are more or less circular in section and are packed with frass which prevents the ingress of enemies. These tunnels become larger with the development of the insects. The grubs destroy a considerable portion of the substance of the rhizome which eventually becomes badly riddled. A single rhizome may harbour several grubs. The larval period occupies from about 3 to 4 weeks, but this period may be prolonged owing to lack of food.

Pupae.—At the end of the larval tunnels, which are usually near the outer surface of the rhizome, the grubs excavate oval cavities or cells in which they pupate. The grubs stop feeding and lie in a comatose condition for about 3 days, and on casting their skins they change into pupae. After a period of 6 to 8 days the adult insects, or weevils, emerge from the pupal skins; at this stage they are chestnut-brown. They usually remain for a few days in the pupal cells until they have attained their normal black colour, after which they may bore their way to the outside. The weevils may, sometimes, leave the pupal chambers before the normal colour has been attained.

The following table shows the life history records of the weevil:

Table showing Life Cycle of *Cosmopolites sordidus.*

No.	Egg.	Larva.	Pupa.	Total egg to adult.
1	6½ dys.	24½ dys.	7 dys.	38 dys.
2	7 ,,	26 ,,	7½ ,,	40½ ,,
3	6½ ,,	22 ,,	6½ ,,	35 ,,
4	7 ,,	26 ,,	7 ,,	40 ,,
5	6½ ,,	24 ,,	9 ,,	39½ ,,
6	7 ,,	26½ ,,	7½ ,,	41 ,,
7	7 ,,	23 ,,	7 ,,	37 ,,
8	6 ,,	28 ,,	8 ,,	42 ,,
9	7½ ,,	21 ,,	7 ,,	35½ ,,
10	7½ ,,	25 ,,	6 ,,	38½ ,,
11	6 ,,	25 ,,	8 ,,	39 ,,

It will be seen from the above table that under laboratory conditions the whole life cycle, from egg to adult, ranges from 5 to 6 weeks, i.e., eggs 6-7½ days, larvae 21-28 days and pupae 6-9 days.

The Stem Weevil.

(*Odoiporus longicollis* Oliv.)

The Plantain Stem Weevil or Stem Borer, so named as it chiefly attacks the stem of plantain, or banana, occurs in plantain gardens as commonly as the Root Weevil. In appearance it is very similar to the Root Weevil but, as will be seen in the two figures 1 and 6 in the plate, it is a little bigger in size. This insect is almost as destructive in habits as the Root Weevil and does serious injury to plantains through the depredations of its larvae, which bore in the stem of the plant. It is especially found in stumps and stems which have been left behind after the bunches have been cut.

Host Plants.

So far as is known in Ceylon plantain, or banana, is its only host plant.

Distribution.

General.—The distribution of this weevil appears to be limited, so far as the writer is aware, to North-East India and Burma, where it has been recorded as a serious pest, (8) and to Ceylon.

Local.—With regard to its local distribution it is fairly well established and widely distributed in the Island and in general is found wherever the Root Weevil is encountered and frequently in association with it.

Description of Stages.

Adult (fig. 6).—Similar in appearance to the Root Weevil but a little larger and more flattened than the latter; slightly longer than 1/2 in. and about 1/5 in. broad; brown when freshly emerged, changing to black after a few days. Rostrum about 1/6 in. long. Antennae elbowed. Elytra striated and not completely covering the abdomen. Legs stout. Both sexes similar in appearance, but the following characters help to distinguish them:—

Male.—Usually slightly smaller than female. Under a lens dorsal surface of about 3/4 of the rostrum towards its apex seen to

be roughened with minute tubercles; base of rostrum, especially its sides, punctate (fig. 6a).

Female.—Dorsal surface of rostrum, excepting the base of it, smooth and shiny; base of rostrum, as in male, punctate. Rostrum also more slender and usually slightly longer than that of male (fig. 6b).

Egg (fig. 8).—About 1/10 in. long by 1/24 in. broad, cylindrically oblong and white.

Larva (figs. 9 and 10).—On hatching nearly 1/8 in. long, whitish except mandibles which are light brown; in a few hours the head also turns brown. Full-grown grub about 1 in. long and a little over 1/3 in. broad, cream coloured, legless, soft and fleshy; head reddish brown; body wrinkled with middle portion swollen; few hairs on body.

Cocoon (fig. 11).—About 1 in. long and 1/2 in. broad, somewhat oval and made of twisted fibre.

Pupa (fig. 12).—About 3/4 in. long by 1/4 in. broad, yellowish white and similar to that of the Root Weevil; before transformation into weevil thep upa turns brown.

Habits and Life History.

Weevils.—The weevils may generally be found in plantain stumps or stems left lying on the ground after removal of bunches or cut down owing to the Bunchy Top disease. They may also be found taking shelter under loose dry plantain sheaths hanging from the stem or surrounding the base of it. In the tunnels of badly riddled and decayed stems they are quite common. The insects avoid light and appear to be active mainly after sunset. They are timid and when disturbed quickly feign death by lying motionless. The weevils are long-lived. The writer has kept them alive in the insectary for about five months when unfortunately the experiment had to be abandoned. In India, Fletcher (8) has kept them alive for a period of two years. Though sluggish at times they appear to be active on the wing. They were observed flying on a few occasions in the laboratory in the day time.

After the insects become sexually mature they begin mating. They mate many times during their lives, the pair remaining *in copula* generally from 5 to 8 minutes. The female weevils start laying eggs in about a month after emergence.

Eggs.—The eggs are laid singly in the cells of the outer plantain sheaths (see fig. 7). They may also be found in the cut surfaces of the stumps or in the inner sheaths of stems lying on the ground. Only one egg is generally deposited in a cell, but very rarely two may be met with. Under laboratory conditions a weevil may lay from one to six eggs a day and on some days no eggs are laid. A pair of weevils collected in the field and found *in coitu* on 14-7-27 and isolated together laid 185 eggs up to 1-12-27, and egg laying was being continued, while another similar pair found mating on the same day laid 103 eggs during the same period.

In laying her eggs the female first bores a small hole through the sheath with her jaws and then turns round and pushes an egg through the hole into the interior of the cell (see fig. 7). The puncture is almost always closed with a black substance, possibly excreta. The incubation period is 3-4 days.

Larvae.—Upon hatching, the tiny grubs bore their way inwards into the stem and tunnel extensive galleries therein and occasionally in the rhizome as well. The tunnels contain frass and in advanced cases the stems are very badly riddled and decayed, converting the inner sheaths into a pulpy rotten mass. The grubs are voracious feeders and consume a large amount of plant tissue. This stage varies from 11 to 18 days, with an average period of about a fortnight.

The full-grown grub of the Stem Weevil is very similar in appearance to that of the Root Weevil, but is nearly twice as large (compare figs. 4 and 10). When the Stem Weevil grub is fully developed it constructs a cocoon of twisted fibre—unlike the Root Weevil grub—inside which it pupates. The Root Weevil grub forms no such cocoon, but pupates in an oval cavity formed in the rhizome.

Cocoons.—The cocoons are generally found inside a leaf sheath where the grubs have been feeding. When the cocoons are fully formed the grubs remain quiet inside without feeding for a few days. This prepupal period varies, generally lasting from 3 to 6 days. During this period they gradually shrink a little and then transform into the pupae.

Pupae.—The pupal period ranges from 7 to 10 days, with an average of about 8 days. On emergence from the pupal skins the weevils are of a brown colour, but in a few days (sometimes in a day) the insects turn completely black. The weevils may remain inside their cocoons for a few days before making their way out into the open, or sometimes weevils which are yet brown may leave the cocoon,

The following table shows the life history records of the weevil:—

Table showing Life Cycle of *Odoiporus longicollis* Oliv

No.	Egg.	Larva	Prepupal period.	Pupa.	Total egg to adult.
1	4 dys.	14 dys.	5½ dys.	7 dys.	30½ dys.
2	4 ,,	14 ,,	6 ,,	8 ,,	32 ,,
3	4 ,,	15 ,,	6 ,,	8 ,,	33 ,,
4	3 ,,	14 ,,	5½ ,,	10 ,,	32½ ,,
5	3 ,,	15 ,,	5 ,,	7 ,,	30 ,,
6	3 ,,	16 ,,	4 ,,	7½ ,,	30½ ,,
7	3½ ,,	15½ ,,	4½ ,,	7 ,,	30½ ,,
8	3½ ,,	17 ,,	5½ ,,	9 ,,	35 ,,
9	3½ ,,	18 ,,	5½ ,,	8 ,,	35 ,,
10	3½ ,,	18 ,,	4 ,,	8 ,,	33½ ,,
11	4 ,,	11 ,,	4 ,,	7 ,,	26 ,,
12	3½ ,,	13 ,,	3 ,,	7 ,,	26½ ,,
13	3½ ,,	13 ,,	4 ,,	8 ,,	28½ ,,
14	4 ,,	15 ,,	3 ,,	7 ,,	29 ,,
15	3 ,,	14 ,,	6 ,,	9 ,,	32 ,,

As will be seen from the above table the whole life cycle, from egg to adult under laboratory conditions occupies from 26 to 35 days, the incubation period being 3-4 days, larval period 11-18 days, with a prepupal period of 3-6 days and a pupal period of 7-10 days.

Control Measures for Both Weevils.

The habits of these two insects render the application of remedial measures extremely difficult, since the larvae feed *within the rhizome* in the case of the Root Weevil or *within the stem* in the case of the Stem Weevil. For the control of these two pests, however, a few agricultural methods of control can be adopted. The following measures therefore are recommended:—

Selecting a new site.—Do not choose a site for a new plantation adjacent to an infested area.

Planting material.—Select only healthy and uninfested suckers for planting. Examine every sucker before planting and discard and destroy any rhizome showing any trace of the insect. Do not allow suckers dug out for planting to lie on the ground overnight as the weevils may enter and oviposit.

Sanitation.—Do not allow stumps to remain and cut stems to lie about the garden. After a bunch is removed cut off the stem as close to the ground as possible. Cut stems with old corms can be sliced into small pieces and buried as deeply as possible, preferably with lime; or they may be sliced and stems cut into halves and exposed to the sun to dry up. A good plan

is also to mix up the chopped up pieces with freshly cut grass or cattle manure to form a compost heap. The heat generated by fermentation destroys the larvae. Collect and burn all trash.

Rotation of crops.—Do not allow a plantation to run for more than three years. At the end of this period the land should be ploughed or dug and left fallow, or some other crop grown for some time, at least a year. Destroy all plantain material.

Infested gardens.—Where a garden is badly infested the total destruction of plants is advisable; but where the infestation is slight dig out and destroy all badly infested stools. Use traps. Destroy plants attacked by the Stem Weevil.

Traps.—Trapping is done by spreading pieces of sliced stems and bulbs with the cut side down on the ground in the neighbourhood of growing plants. The weevils congregate on the under surfaces of these slices and in stems where they should be collected and destroyed daily. Renew baits frequently at least once a fortnight and *destroy* old pieces, which will probably contain eggs and grubs.

The above cultural methods can be easily adopted by small cultivators for the simple reason that they can be carried out regularly and systematically as a part of the routine of general agricultural practice. They will provide effective and simple means of keeping these pests under control without the use of expensive insecticides.

Acknowledgement.

The writer's thanks are due to Dr. J. C. Hutson, Entomologist, for valuable advice and kind assistance given in the preparation of this article.

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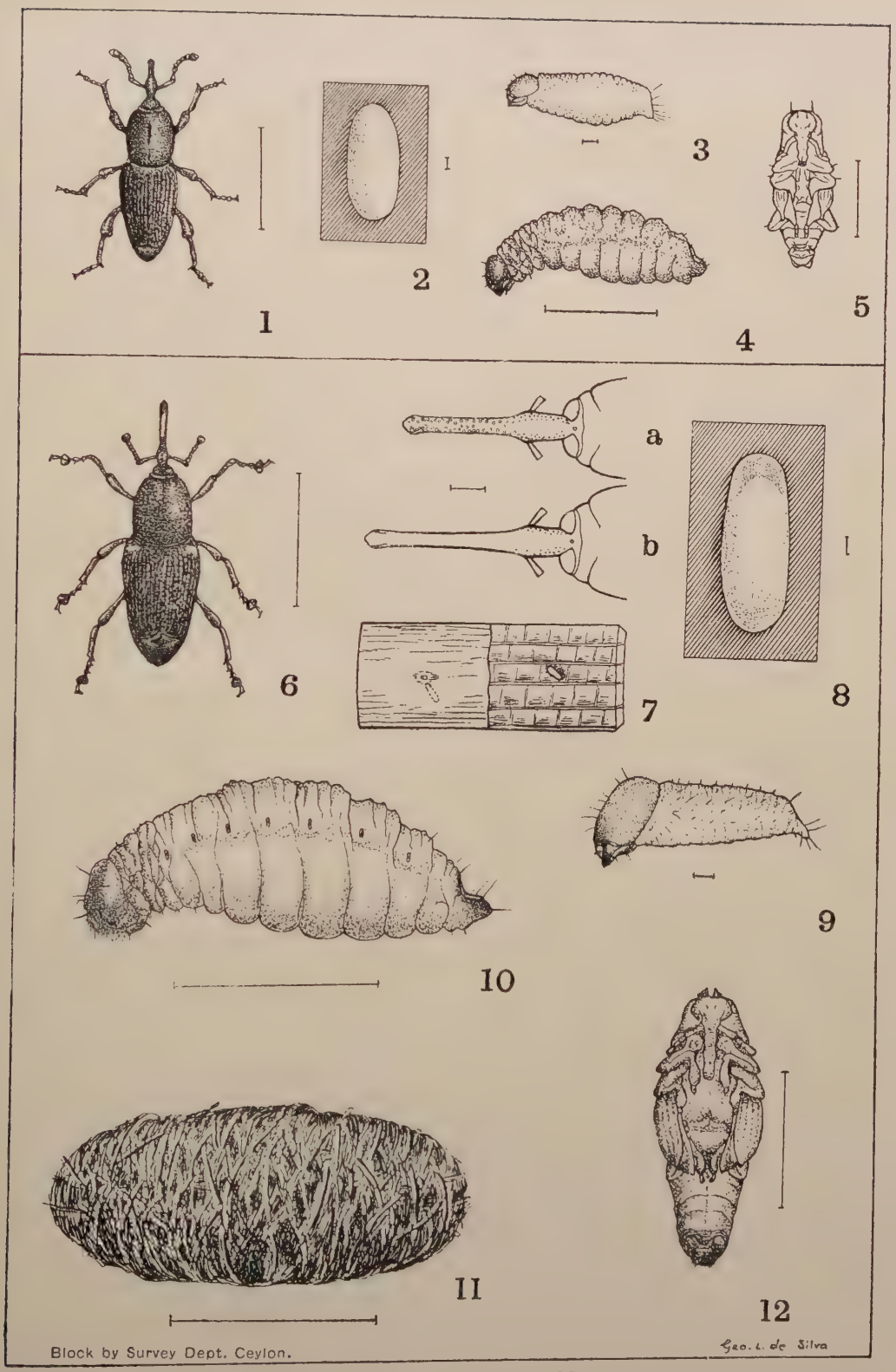

THE TWO PLANTAIN WEEVILS.

(*Cosmopolites sordidus* Germ. and *Odoiporus longicollis* Oliv.)

(1). Root Weevil x 2. (2). Root Weevil egg x 10. (3). Root Weevil young larva x 10. (4). Root Weevil full grown larva x 2. (5). Root Weevil pupa x 2. (6). Stem Weevil x 2 (a). Stem Weevil rostrum of male x 6. (b) Stem Weevil rostrum of female x 6. (7). Section of sheath with egg *in situ* in cell nat. size. (8). Stem Weevil egg x 10. (9). Stem Weevil young larva x 10. (10). Stem Weevil full grown larva x 2. (11). Stem Weevil cocoon x 2. (12). Stem Weevil pupa removed from cocoon x 2.

The lines at the side of the figures show the natural size.

Mycological Notes (12).

Hevea Stem Disease Caused by *Fomes lamaoensis.*

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FOMES LAMAOENSIS is well known as the cause of a root rot of *Hevea* but it has not been recorded hitherto attacking the stem at a considerable height from the ground, independently of disease on the roots.

Stem disease of *Hevea* was reported from an estate in the Kalutara district. Specimens of rotten wood received were light and friable and permeated throughout by brown sheets of fungus mycelium which in section appeared as typical brown lines. The estate was visited by the writer and the affected trees examined. It was found that two trees, a considerable distance apart, were attacked. In both instances the fungus had gained an entry at some distance from the ground and the subsequent ringing of the stems had caused the dying back of the crowns of the trees. It had been found possible to pollard one tree below the diseased tissue but the other had been more severely attacked with the result that the upper part had been blown over by the wind necessitating the removal of the tree.

The roots of both trees were examined critically and were found to be healthy, and, similarly, sections of the trunk below the diseased portions were unaffected. It was apparent that the fungus had gained an entry at a cankered fork in one tree, and in the other the rot had probably started through the wood exposed by the removal of a lateral branch. The surface of the bark of affected areas was covered by a growth of lichens, mosses and saprophytic fungi and the marked development of these may be explained by the presence of the hyphae of the fungus in the cortex, since hyphae of *Fomes lamaoensis* are covered with a gelatinous sheath and this by imbibing water ensures a moist substratum upon which the epiphytes thrive. The same characteristic of the hyphae causes the adherence of sand and small

stones to roots affected by the fungus. As has been mentioned above, the diseased wood was permeated by sheets of brown mycelium. In advanced cases the wood was light and friable and showed the honeycomb structure which is caused by the persistence of the sheets of mycelium after the intervening wood has almost completely decayed.

Infection is most probably caused by spores which find an entry through wounds into exposed wood and, seeing that such wounds are not very common, it is unlikely that the disease will ever be serious. The possibility of infection, however, adds emphasis to the need of continued attention to the common estate practice of tree surgery and sanitation. Canker patches, at forks particularly, should be kept clean and wood exposed by the cutting of branches should be treated periodically to prevent the entry of wood-rotting fungi.

Infected trees should be treated on their merits. Some can be saved by cutting or pollarding below the infected portion; in every case the diseased tissue should be burnt.

Mycological Notes (13).

Further Notes on *Rhizoctonia bataticola.*

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SEVERAL new hosts of *Rhizoctonia bataticola* are recorded in these notes and several points of general interest are discussed. The total number of Ceylon hosts of the fungus now exceeds fifty. On scientific grounds the *Rhizoctonia* would be named more correctly *Macrophomina Phaseoli* (Maubl.) Ashby, but the *Rhizoctonia* name is retained and used in these notes for reasons of local convenience and in order to avoid confusion. *Macrophomina Phaseoli* is the pycnidial stage of the soil *Rhizoctonia*; it formed the subject of Mycological Notes (9). In Ceylon the *Macrophomina* has been found in culture and in nature on beans only.

(a) (1) *Phaseolus vulgaris* L. (Rodriguez Beans). Examples of root disease due to *Rhizoctonia bataticola* have occurred among Rodriguez beans grown on the Bata-ata and Middeniya Cotton Rotation Stations in the Southern Province. The same root disease of French beans, another variety of *Phaseolus vulgaris*, and also the ashy stem blight due to attacks of *Macrophomina Phaseoli*, the pycnidial stage of the *Rhizoctonia*, were reported in Mycological Notes (6) in the *Tropical Agriculturist* of July, 1927. It was pointed out then that the sclerotial *Rhizoctonia* root disease occurred independently of the pycnidial *Macrophomina* stem disease, and it was noted in the present case of Rodriguez bean root disease that the *Macrophomina* occurred, not on the stems of the plants which, by the way, showed no sign of ashy stem blight, but on the dried-up skins of the pods of two of the specimens. The pycnidia of the *Macrophomina* were very numerous, and the spores were proved to give in culture the sclerotial *Rhizoctonia* form of the fungus. In the case of Rodriguez beans, then, the *Rhizoctonia* form of the fungus occurred on all the specimens and the *Macrophomina* form on two

of them only; the presence of the *Macrophomina* on the pods did not follow of necessity the presence of the *Rhizoctonia* on the roots. Rodriguez beans have been attacked also by eelworm (*Heterodera radicicola*) in the northern part of the island.

(2) *Cocos nucifera* L. (Coconut). *Rhizoctonia bataticola* has been recorded on the roots of coconuts in the Eastern Province, an extension of its known distribution on this host in Ceylon. It occurred on trees which were subjected to periodical flooding. It has also been found to attack the roots of coconuts growing under normal conditions at Kadugannawa.

(3) *Hevea Brasiliensis* Müll.-Arg. (Rubber). A case of *Rhizoctonia* attack on a budded rubber stump has been encountered. Certain of the smaller roots and the tap-root of the stump showed the presence of large numbers of small sclerotia both in the cortical tissues and on the wood. Similar root diseases of young stumps of *Eucalyptus* and jak have been encountered. It may be mentioned that the budding of the rubber stump in question had been successful.

Investigation of root disease of certain old rubber trees in plot 1 (planted 1877) and plot 2 (planted 1887) at Heneratgoda disclosed the presence of the *Rhizoctonia* and *Fomes lamaoensis*, the fungus of brown root disease, on larger roots and the *Rhizoctonia* alone on smaller roots. Trees which had not been attacked by root disease and which were in a normal healthy condition adjoined the diseased trees, and it was noted that their roots were in close contact with diseased roots affected by the brown root fungus. They might therefore have been expected to become diseased through spread of the brown root fungus by contact, but they had not been affected in any way and had remained healthy. The brown root fungus was confined to roots already attacked by the *Rhizoctonia*. It was apparent from the condition of roots attacked by the *Rhizoctonia* and the brown root fungus that the latter had had time to attack adjacent healthy roots if it had been capable of doing so.

(4) *Nicotiana Tabacum* L. (Tobacco). An interesting case of root disease of young tobacco showed the presence on all affected plants of both *Rhizoctonia bataticola* and eelworm (*Heterodera radicicola*). Certain roots of the plants had been attacked by the *Rhizoctonia* only, others by the eelworm only; others again had been attacked by both fungus and eelworm. It has already been reported that both the *Rhizoctonia* and the eel worm are associated with a diseased condition of plantain roots in Ceylon, but, while both agents of disease have been found on separate roots of the same plantain, they have not been found in company on the same root. In the case of tobacco, it is difficult to apportion between fungus and eelworm the blame for root disease. Simple eelworm attack on tobacco roots is not uncom-

mon in Ceylon. The *Rhizoctonia* may have followed the eelworms, but, again, the conditions under which the plants were growing may have been so unsuitable that both agents were enabled to attack the plants in their presumably weakened state. The plants, however, did not show any outward signs of weakness of root and stem development. The case of attack by both fungus and eelworm on plantain roots may be similar to that of tobacco.

(5) *Albizzia lopantha* Benth. (Cape or Crested Wattle). A case of root disease of a two-year old plant showed *Rhizoctonia* in the roots and *Poria* on the collar. The latter fungus had not penetrated its substratum; the roots attacked by the *Rhizoctonia* were dried and hardened in a typical manner.

(6) *Citrus*. Two cases of *Rhizoctonia* root disease of young plants of mandarin orange have been encountered on the Experiment Station, Peradeniya. In one case, fifty per cent. of the roots of the plant had been attacked.

(7) *Persea gratissima* Gaertn. (Avocado Pear). *Rhizoctonia* root disease of well-grown trees has occurred on the Experiment Station, Peradeniya. With reference to the reported correlation between deficiency of soil potash and prevalence of *Rhizoctonia* disease of jute, it may be noted that an analysis of the soil of the avocado plot carried out by the Agricultural Chemist of the Department of Agriculture showed a deficiency of phosphoric acid rather than of potash.

(8) *Eucalyptus globulus* Labill. (Blue Gum). *Rhizoctonia* lines or sclerotial plates occurred in the root tissues of blue gum seedlings attacked and killed by the fungus. A pycnidial fungus which occurred on the dead stems of the plants resembled closely *Macrophomina Phaseoli* but proved to be a species of *Macrophoma*.

(9) *Santalum album* L. (Sandalwood). *Rhizoctonia* root disease of a young specimen of this tree occurred also on the Experiment Station, Peradeniya. Sclerotia were present in the roots and hyphae of the *Rhizoctonia* were found in plenty in the inner cortical root tissues.

(10) *Desmodium heterocarpum* DC. This plant is used as a cover and green manure in rubber. It has been found to die out in patches. Sclerotia and lines occur in diseased roots.

(11) *Livistona Australis* Mart. Lines or sclerotial plates of the *Rhizoctonia* were found in diseased roots of a specimen of this palm in the Royal Botanic Gardens, Peradeniya.

(12) *Elettaria Cardamomum* Maton. (Cardamom). Investigation of a recent case of death of cardamoms in patches disclosed a dry hardened condition of the roots of diseased plants.

The roots also contained thin black lines from which the *Rhizoctonia* was grown in culture. The lines in the cardamom roots and the isolations of the fungus recalled the lines and *Rhizoctonia* isolations of the same root disease of guinea grass reported in Mycological Notes (8) in the *Tropical Agriculturist* of October, 1927. The cardamom root disease is followed by a rot of the rhizomes of affected plants.

(b) A speaker at a local meeting which was reported in the *Times of Ceylon* of November 5 of last year discussed the question of the apparently sudden death of a rubber tree on the smaller roots of which the *Rhizoctonia* was found subsequently. He said he was of opinion that "the disease "of a certain amount of rootlets could not have killed the tree "in such a short period as four days" and "he surmised, "though he might have been wrong to do so, that death was "due probably to lightning and *Rhizoctonia* was secondary." It is to be noted that there were no signs of lightning injury to the tree and that the roots were reported to be healthy. The fungus was found to have attacked the majority of the small roots submitted for examination, and it is possible that its attack accounted for the death of the tree. In this connection, the writer had experience in Uganda of a similar sudden death of adult plants of robusta coffee on two occasions, and C. G. Hansford, the present Mycologist of the Department of Agriculture, Uganda, has reported (*in litt.*, Jan., 1928) that he has encountered further cases of the sudden death of robusta coffee due to *Rhizoctonia* root disease and also that the disease is not confined to plants growing under poor soil conditions. On both occasions in the writer's experience, single trees in the midst of hundreds of other healthy robusta plants were found to have died with such suddenness that the usual gradual degeneration and dieback were totally absent. In both cases, the leaves of the plants remained on the trees in a browned and dry condition, and in both cases it was reported that the trees had apparently been in perfect health a few days previous to death. The *Rhizoctonia* of these notes was the only fungus present and it was found to have penetrated and permeated the root systems of the plants so thoroughly and regularly that its reaching a certain point caused a complete and sudden stoppage of water supply from the roots, a stoppage which led to rapid wilting and death. The fact that the leaves were not shed in the usual manner pointed to a sudden complete interference with the movements of moisture or sap within the plants, and it is possible that the case of sudden death of the rubber tree was similar to those of the coffee. The writer would be glad of an opportunity of investigating similar cases in the field.

With reference to the point that the *Rhizoctonia* followed the results of lightning injury, the writer holds that the

Rhizoctonia is unlikely to do so. There is no evidence to the effect that the *Rhizoctonia* behaves in the manner stated, that is to say, that it is capable of living on any dead material that may be at hand. It has not been found, for example, on the dying and dead roots of shade trees which have been cut down in areas of tea and cacao known to contain the *Rhizoctonia*.

(c) It is necessary to protest against the application of the term " root-rot " to root disease with which the *Rhizoctonia* is associated. In the case of the majority of the host plants, the term is particularly unsuitable because the *Rhizoctonia* does not cause a rot; on the contrary it renders affected tissues dry and comparatively brittle. The term " *Rhizoctonia* root disease " is more suitable than " root-rot."

(d) The *Rhizoctonia* has been found lately on tea (both seedlings and older plants) in Java, on *Acacia melanoxylon* in Kenya, on *Eucalyptus rostrata* in Southern Rhodesia, on rubber in Malaya, and on cotton and citrus in the West Indies. During 1927 new records of its attack on *Panax*, *Buddleia*, orange, lemon and roses have been made in Uganda by Hansford. Its recently-discovered presence in cases of rubber root disease in South India and Uganda has been noted in the *Tropical Agriculturist* of October, 1927. These new records support the writer's contention that the *Rhizoctonia* is widely distributed in the tropics and sub-tropics. It is possible that a careful search will disclose the presence of the fungus in regions from which it has not yet been recorded and its association with root disease of plants of economic importance in those regions.

The finding of the *Rhizoctonia* on tea in Java towards the end of 1927 followed closely upon the publication of an article by Dr. A. Steinmann of the Proefstation voor Thee at Buitenzorg in *De Bergcultures* of September 10, 1927 in which it was stated that the *Rhizoctonia* had not been found in Java. The article ended with the statement that *Rhizoctonia bataticola* had to be added to the list of root fungi of tropical cultivated plants. The results of further investigation in Java, particularly investigation into the presence of the *Rhizoctonia* in cases of tea root disease in which fungi like *Poria*, *Ustulina* and *Diplodia* are also present, are awaited with interest.

Contribution from the
Rubber Research Scheme.

Notes on Rubber Manufacture.

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Sodium Silicofluoride as a Coagulant.

SODIUM silicofluoride (also known in trade circles as fluosilicic soda) is a greyish-white powder which occurs as a bye-product in the manufacture of superhosphates. It is used to some extent as an insecticide and also has fungicidal properties.

J. Edwardes,* Chemist to the Rubber Growers' Association in Malaya, experimented with S. S. F. as a preventive of mould in smoked sheet and noted that it was also a rubber coagulant. As regards mould prevention it was found that soaking sheets in a solution of S. S. F. prevented mould to a large extent, but it was less efficient for this purpose than para nitrophenol. The properties of S. S. F. as a coagulant were investigated and at the same time exhaustive tests were made by H. P. Stevens† to determine its effect on the inner properties of the rubber. The conclusion was reached that S. S. F. is a useful and economical coagulant without material influence on the inner properties of the rubber and its use was approved by the Rubber Growers' Association in 1925.

The method of use advised by the Rubber Growers' Association is as follows:

The latex should be diluted to $1\frac{1}{2}$ lb. per gallon. The amount of S. S. F. required is 1 lb. to 150 gallons of diluted latex (i.e., 1 lb. to 225 lb. rubber). The weighed quantity of the chemical should be introduced into the coagulating tank and the diluted latex run in and thoroughly stirred.

* R.G.A. Bulletin. January, 1923. p.21.

† R.G.A. Bulletin September, 1925. p.555.

The advantages and disadvantages of S. S. F. as a coagulant are approximately as follows:

Advantages.

1. Being a non-corrosive solid it is easier to transport and handle than acetic or formic acid.
2. It is cheaper than Acetic acid.
3. It has certain fungicidal properties.
4. It has a remarkable influence in preventing bubbles in sheet rubber.

Disadvantages.

1. Being a solid it must be weighed instead of measured, which is probably less accurate under estate conditions.
2. It has a low solubility (0·84%) which means that it must be used in solid form or else as a very dilute solution.
3. It is a relatively weak coagulant, and therefore does not give complete coagulation unless the latex is diluted to $1\frac{1}{2}$ lb. per gallon.
4. It has a corrosive action on aluminium.

The properties of S. S. F. have also been carefully investigated by a number of workers in Java* and by N. H. Van Harpen in Sumatra.† The results reported from Java are much less satisfactory than those from Malaya, it being found that in many cases complete coagulation cannot be obtained even when the latex is diluted to $1\frac{1}{2}$ lb. per gallon, and that on the average the amount of coagulant required is more than twice that which is found to give satisfactory results in Malaya. It is also found that latex from various divisions of the same estate may behave differently on treatment with S. S. F. The reason for this was investigated by L. R. Van Dillen‡ who concludes that it is due to differences in the acidity of the original latex. The general conclusion reached in Java is that the use of S. S. F. is not to be recommended except in special cases for prevention of bubbles in sheet manufacture.

Results from Sumatra are more in line with those reported from Malaya, and the use of S. S. F. is recommended both as an economy and on account of its action in preventing bubbles in sheet. Van Harpen gives figures for an estate on which the proportion of off-grade sheet was reduced from 39% to 6·9% (average for 3 months) by adoption of S. S. F. It is pointed out that the use of the coagulant in powder-form is not to be recommended and that it should be made up in the form of a 0·5% solution. In this case it is claimed that coagulation at $1\frac{1}{2}$ lb. per

* Messrs. L. R. Van Dillen, C. Knaus, G. M. Kraay & R. Riebl. Archief Feb. 1928. p.127.

† Archief Dec. 1926. p.617, & Oct. 1927 p.487.

‡ Loc. cit.

gallon gives consistently satisfactory results. It has also been shown by the same worker that latex of 2 lb. per gallon can be satisfactorily coagulated if a small proportion of formic acid is added to the solution of S. S. F.

A few experiments were carried out by the Ceylon Rubber Research Scheme when S. S. F. was first introduced in Malaya. These laboratory tests indicated that S. S. F. in the proportion 1·200 gave good coagulation at $1\frac{1}{2}$ lb. per gallon leaving a clear or opalescent serum and that soaking sheets in a solution of S. S. F. after rolling, increased resistance to mould growth. It was thought however that a coagulant used in powder-form was not suited to Ceylon conditions and the investigation was not continued. Several enquiries were received on the subject a few months ago and it was thought advisable to make further tests to see whether S. S. F. could be used successfully in Ceylon. The experiments are not completed and the present notes are compiled with the object of giving the information which is at present available.

Experiments on the Method of Using S. S. F.

The method recommended by the R. G. A. is that the required amount of the chemical should be introduced into the coagulating tank, and the standardised latex run in and stirred. This would be inconvenient in Ceylon where it is customary to coagulate in a number of Shanghai (50 gallon) jars.

The method adopted by the Sumatra and Java workers is to use the chemical in the form of a 0·5% solution. Approximately 8 gallons of solution is required to coagulate 1 jar of latex at $1\frac{1}{2}$ lb. per gallon, which would entail having a large mixing tank for the solution.

Tests were made in Ceylon to determine whether it would be satisfactory to add the chemical to the latex in the form of a suspension in water. S. S. F. "wets" readily and if it is first kneaded by hand with a little water it forms an even suspension when stirred up with the requisite quantity of water. This method of use gave good results in laboratory tests and two factory tests have been carried out. One test was made in the Kalutara district (approximate annual rainfall 150 inches), and the other in the Moneragalla district (approximate annual rainfall 80 inches), during wet weather.

Details of the tests were as follows:—

A.—Kalutara District.

50 gallons of latex diluted to $1\frac{1}{2}$ lb. per gallon. $6\frac{1}{2}$ ounces of S. S. F. (i.e., 1 part S. S. F. to 180 parts dry rubber) was well mixed with 2 gallons of water and added to the jar of latex. The latex was stirred for 4 minutes and then distributed to enamelled coagulating pans.

The following morning coagulation in all pans was complete leaving a clear serum. The coagulum was somewhat softer than with a similar amount of Acetic acid, but worked up into good sheets.

B.—Moneragalla District.

50 gallons of latex diluted to 1 lb. 7½ oz. per gallon. 6½ ounces of S. S. F. mixed with 3 gallons of water and added to the jar of latex, stirred for 3 minutes and distributed to wooden troughs.

The following morning the coagulum was somewhat soft but worked up into good sheets. The serum was milky. A jar of the same latex coagulated with a similar quantity of Acetic acid gave a harder coagulum and a less milky serum.

It will be seen from the above results that coagulation was completely successful in one test but resulted in a small loss of rubber in the other test. This loss was probably not greater than is incurred daily in a number of factories using acetic acid, but was nevertheless unsatisfactory.

The value of a mixture of S.S.F. and acid for coagulation at 2 lb. per gallon was indicated by Van Harpen, and it is considered by the present writer that under Ceylon conditions it would be advisable to extend this to all coagulation with S. S. F. For sheet manufacture at 1½ lb. per gallon it is thought that S. S. F. in proportion 1·200 plus formic acid in proportion 1·1600 would give a coagulum of suitable hardness and a clear or opalescent serum.

The properties of latex vary on different estates and S. S. F. appears to be sensitive to such variations, so it would be necessary for each estate to establish by tests the proportion of S. S. F. and acid required to give satisfactory results.

Influence of S. S. F. in Prevention of Bubbles in Sheet.

Up to the present two tests have been carried out to determine this point.

A.—Laboratory Test.

Latex brought in to the laboratories at noon was kept until 4 p.m. It was then diluted to 1½ lb. per gallon. One pan was coagulated by means of acetic acid (1·180) and the other by S. S. F. (1·180).

On examination after smoking it was found that the S. S. F. sample was entirely free from bubbles. The acetic acid sample contained numerous bubbles.

B.—Factory Test in Moneragalla District.

This Estate was visited for the purpose of advising on the cause and prevention of bubbles in smoked sheet. The bubbles were of the type usually attributed to premature clotting of the

latex and it was concluded that the trouble was chiefly due to climatic conditions.

Observations on the effect of S. S. F. in prevention of bubbles were made on the sheets obtained from the coagulation test described in the previous paragraph. It should be mentioned that latex for this experiment was taken from the field with the worst reputation for producing bubbly sheet. Both batches of sheet were coagulated in old wooden troughs.

One sheet from each batch was forwarded to the writer for examination. The S. S. F. Sheet was entirely free from bubbles and was very attractive in appearance. The Acetic acid sheet was badly disfigured with bubbles and would probably be valued at about 5 cents per lb. less in the local market. The Superintendent reported that these sheets were typical of the remainder.

These results confirm reports from Malaya and Sumatra that S. S. F. has a remarkable influence in preventing bubbles in sheet and the writer considers that this is one of the chief points in favour of S. S. F. as a coagulant. Unfortunately it has to be remembered that S. S. F. cannot be used in conjunction with aluminium pans and this would hinder its adoption on many estates.

Coagulation of Latex at 2 lb. per gallon.

In crepe manufacture in Ceylon it is usual to coagulate at a dilution of 2 lb. per gallon. Coagulation with S. S. F. at $1\frac{1}{2}$ lb. per gallon would involve an increase of 33% in the number of jars for the same crop.

As mentioned earlier in the report Van Harpen has shown that coagulation at 2 lb. per gallon can be carried out successfully if a small proportion of the S. S. F. is replaced by acid. One test on these lines was carried out by the Writer with the following results.

Nature of coagulant.	Appearance of serum (after 18 hours).
1. Acetic acid (1·200)	Very milky.
2. $\frac{7}{8}$ dose Acetic acid plus $\frac{1}{8}$ dose S.S.F.	Less milky than 1 (similar to 9).
3. $\frac{3}{4}$,, ,, ,, ,, $\frac{1}{4}$,, ,,	Less milky than 2.
4. $\frac{5}{8}$,, ,, ,, ,, $\frac{3}{8}$,, ,,	Opalescent.
5. $\frac{1}{2}$,, ,, ,, ,, $\frac{1}{2}$,, ,,	Opalescent.
6. $\frac{3}{8}$,, ,, ,, ,, $\frac{5}{8}$,, ,,	Opalescent.
7. $\frac{1}{4}$,, ,, ,, ,, $\frac{3}{4}$,, ,,	Milky (similar to 3).
8. $\frac{1}{8}$,, ,, ,, ,, $\frac{7}{8}$,, ,,	More milky than 7.
9. S.S.F. (1·200)	More milky than 8 (similar to 2).
10. S.S.F. (1·200) plus $\frac{7}{8}$ dose acetic acid.	Less milky than 9 (similar to 7).

The test is not entirely satisfactory in that coagulation with acetic acid (1·200) gave a milky serum in this case. It indicates however that successful coagulation of latex for crepe manufacture is likely to be achieved by the use of S. S. F. in conjunction with a small quantity of acid, e.g., full dose of S. S. F. plus formic acid in proportion 1 to 1600. It is intended to carry out further tests on these lines as soon as tapping is resumed.

Comparison of Coagulation Costs.

The latest quotations from Colombo for the various coagulants are as follows.

Acetic acid Rs. 19·00 per carboy of 45 lb.

Formic acid Rs. 18·00 per carboy of 45 lb.

S. S. F. (average of 2 quotations) Rs. 18·50 per cwt.

Cost of Coagulating 100,000 lb. of Rubber.

		Saving compared with Acetic acid.
Acetic acid (1·200)	Rs. 211·10	—
Formic acid (1·350)	,, 114·30	Rs. 96·80
S. S. F. (1·200) plus Formic acid (1:1600)	,, 107·60	Rs. 103·50

Conclusions.

1. Sodium silicofluoride has been used successfully as a coagulant in Malaya and Sumatra. Reports from Java are less satisfactory. Experiments indicate that it is likely to be a useful coagulant under Ceylon conditions when used in conjunction with a small proportion of acetic or formic acid.

2. Adoption of formic acid or sodium silicofluoride as a coagulant leads to a considerable reduction in the cost of coagulation.

3. Sodium silicofluoride has a remarkable influence in the prevention of bubbles (due to premature clotting) in sheet.

4. Sodium silicofluoride cannot be used in conjunction with aluminium utensils.

5. Further experiments are required in Ceylon, particularly with regard to the effect of S. S. F. on the colour of blanket crepe. Reports from Java indicate that the dose of sodium bisulphite can be reduced by 50%.

Para Nitrophenol for Prevention of Fungal Spots in Crepe.

The use of para nitrophenol (p.n.p.) as a preventive of mould in smoked sheet is now well established in Ceylon, and it would be useful if it could also be employed for prevention of spots in crepe during manufacture and storage.

Spotting of crepe during drying can usually be traced to lack of ventilation in the drying rooms and should not occur even in unfavourable weather if the drying rooms are properly ventilated. The fact remains however that a number of Estates in Ceylon have trouble with fungal spots or surface mildew in crepe during the monsoons and there is no doubt that there is scope for an efficient disinfectant for use in crepe manufacture. Also in the present state of the rubber market it is necessary at times to store rubber for considerable periods, and in spite of careful manufacture spots are liable to develop if the rubber is stored under unfavourable conditions. The writer knows from experience that most of his crepe samples develop a good growth of fungal spots in the course of a year's storage at the laboratories.

H. C. Pinching* showed that soaking wet crepe in a 0·15% solution of p.n.p. prevented spotting and found that the treatment did not affect the colour of the crepe. A later recommendation of the Rubber Growers' Association† is that a 0·1% solution of p.n.p. should be used. Experiments in Ceylon indicate that soaking in 0·1% p.n.p. solution is effective but causes slight discoloration of the crepe. The degree of discoloration varies in different samples of latex but appears to be worst during wet weather which is when a disinfectant is most required. In comparing the results it should be remembered that crepe in Malaya is marketed in the form of "lace," and that slight discoloration which is not noticeable in lace crepe becomes evident when it is rolled into blanket.

W. Brown‡ investigated the causes of spots in crepe and found (in London) that soaking in a 0·01% solution of p.n.p. effectively prevented development of spots. Laboratory experiments in Ceylon indicate that this treatment does not entirely prevent spotting when the samples are kept in an atmosphere saturated with moisture, but would probably be effective under ordinary conditions of manufacture and storage. Unfortunately even this low concentration of p.n.p. leads to slight discoloration of blanket crepe. Moreover when the treatment was applied under estate conditions, viz: soaking 50 lb. of lace crepe in a Shanghai jar of solution it was found difficult to ensure thorough

* R.G.A. Bulletin, Sep. 1924. p.545.

† R.G.A. Bulletin, Sep. 1925. p.560.

‡ R.G.A. Bulletin, Nov. 1924. p.682. & R.G.A. Bulletin, Sept. 1925. p.522.

soaking, with the result that parts of the crepe were no more resistant to spotting than the untreated crepe.

The alternative method of using p.n.p. is to add it to the latex with the acid used for coagulation. Addition of 0·1% of p.n.p. (based on dry weight of rubber) prevents spotting but causes slight discoloration of the finished blanket. Experiments made recently indicate that ·025% of p.n.p. (i.e., 1 part p.n.p. to 4000 parts rubber) can be added to latex without having any effect on the colour of the rubber. In the latest experiment two chests of rubber were prepared from one batch of latex, one containing ·025% p.n.p. and the other without p.n.p. No difference in appearance could be detected, nor was there any streakiness when portions of treated and untreated crepe were blanketed together.

The resistance of the rubber to spotting was tested by keeping portions of wet lace crepe in an atmosphere saturated with moisture. The appearance of the samples after the test was as follows:—

After 7 days.

Control.—Many black and greenish spots.

Sample containing ·025% P.N.P. One yellow spot.

After 18 days.

Control.—Almost covered with black spots and surface mould.

Sample containing ·025% P.N.P. One yellow spot and some small pink spots.

The treatment was not sufficient to prevent spotting completely under this severe laboratory test but it is considered that it would be an effective preventive under normal conditions of manufacture and storage.

It remains to be seen whether this proportion of p.n.p. can be added to latex at all seasons without affecting the colour of the finished crepe, but anyone who is troubled with spotting of crepe is advised to experiment with this method of control.

The easiest way to incorporate the correct dose of p.n.p. in the latex is to dissolve the chemical in the undiluted acid (acetic or formic) used for coagulation. On the basis that one carboy (45 lb.) of acetic acid coagulates 9000 lb. of rubber the amounut of p.n.p. per carboy of acid is $2\frac{1}{4}$ lb. It is advisable to empty the contents of the carboy into a Shanghai jar, mix in the chemical and then replace the acid in the carboy. If mixed in bulk in this way there is little danger of mistakes in the amount of p.n.p. added to the latex. Alternatively a 1% solution of p.n.p. in water can be made by dissolving 1 lb. p.n.p. in 10 gallons of water and the correct dose added to the diluted acid used for coagulation. Coagulating at 2 lb. per gallon the dose for a 50 gallon jar would be 2 pints.

Birds in Relation to Agriculture.

N. K. JARDINE, F.E.S.,

Plant Pest Inspector, Central.

IT has been suggested that a report which enumerates the birds that feed on Tea Tortrix would be useful to planters in order that they may know what species to attract to estates, and how best to attract them.

The suggestion opens the very important question of the utility or otherwise of birds to Agriculture. The question is one which has occupied the attention of entomologists, ornithologists and those who have had practical experience of the damage and the good that can be done by birds, all over the world, and the evidence is so conflicting that one doubts whether this vexed question will ever be solved.

Birds are known to destroy fruits, seeds and crops; to damage forest trees and wantonly to destroy young buds of trees and bushes; to destroy beneficial insects and to distribute injurious ones; to disseminate weeds; to attack game-birds, poultry and young stock, and to be harmful to fisheries. But they are also known to do good by destroying injurious insects, seeds, birds and mammals, and by scavenging.

Some birds are known to be wholly injurious, others to be wholly beneficial, but there is a very large class of "doubtfuls," and in view of the lack of evidence as to the actual food of the doubtfuls at different seasons of the year, and under varied conditions, it is not yet possible to say how the balance weighs.

So far as Ceylon is concerned there is little evidence of the value of any of our insect-feeding birds outside of "personal opinion," and consequently several of them have been given exaggerated reputations for usefulness.

No definite conclusion can be made of the utility of a bird without a knowledge of its feeding habits, and this can only be ascertained by an examination of the stomach contents. During the writer's investigation into Tea Tortrix two hundred White-eyes were taken from tortrix-infested fields, and the stomach contents examined. The result of the examination showed that none of them had fed on tortrix.

It is not yet possible to enumerate the birds that feed upon Tea Tortrix, for what information there is on the subject at present is only "personal opinion." All that can be said is that such and such a bird *may* devour the pest. No bird will feed exclusively on tortrix. To attract a species of bird to an estate in the hope that it will devour the pest, is an act to be undertaken with care and forethought otherwise it may become a veritable pest itself by doing damage to vegetables, flowers and trees, and disseminating weeds and noxious insects.

Inquiries have been addressed to the Department of Agriculture as to what trees it would recommend should be planted in order to attract birds to estates. Something of the habit of the birds must be known before measures to attract them are employed. To plant up trees a bird is known to inhabit does not necessarily mean the bird will come and frequent those trees. Such details as climate, elevation, food and nesting requirements are to be considered. The question of the usefulness of birds is so complex that it is doubtful if a Department would be prepared to make any recommendation in view of the scarcity of adequate knowledge of the utility of our local insect-feeding species.

The following few facts and questions will, it is hoped, assist the reader to appreciate the problem of birds in relation to agriculture, and to judge for himself what is best in his own particular circumstances.

In some cases where birds are always killed and are practically non-existing as in parts of France, Italy and Belgium, and grape-growing districts, insects and pests are not so harmful and weeds are no more abundant, than where birds exist.

No insectivorous bird feeds exclusively upon injurious insects; beneficial insects are just as likely to be devoured.

There is no moth or butterfly known to be wholly beneficial, and stomach contents of insectivorous birds show a preponderance of flies, spiders, ants, grubs, caterpillars, beetles, crickets, grasshoppers, aphids, bees, wasps, and bugs, over moths and butterflies. Do the large wing surfaces of moths and butterflies render them unattractive as regular food ?

It is an acknowledged fact that birds congregate where their food is most abundant. If there are birds in the island partial to a diet of butterflies, where are those birds when the flights of myriads of butterflies are in progress ? The argument that the flights are restricted to low elevations and the lepidopterous-feeding birds to the hills, and that the two do not therefore meet, is refuted in the fact that flights are seen at all elevations, but few, if any, birds are seen to feed upon the butterflies. There have been serious outbreaks of the dadap defoliator (*Taragama*

dorsalis Wlk.) but few, if any, birds have devoured the caterpillars. Plagues of the Albizzia defoliator (*Terias silhetana* Wall) have remained unaffected by the insect-eating birds frequenting the trees at the time.

Moths are mainly nocturnal: insectivorous birds are not. The Tortrix moth is inactive during the day sheltering in the leaves of the trees and bushes. It is active in the evening and during the night. Insect-feeding birds are asleep during the right. Is it therefore probable that birds influence the number of tortrix moths to any extent ? The Tortrix larvae are sheltered during the day in the curled leaves of the food plant. For insect-feeding birds to devour tortrix larvae it is necessary for the birds to extract the larvae from the tightly bound flush. Is it probable a bird will undertake this difficult method of procuring food when other insect food is abundantly to hand in the form of the many varieties of accessible insects in every tea bush ? In view of these points is it possible that birds influence the numbers of this pest ? And is it likely Tea Tortrix is going to be checked by attracting birds to tea estates ?

Insect-feeding birds move in search of food during the day. Insect parasites and beneficial insects mainly move during the hours of daylight. Is it therefore not probable that these beneficial insects are preyed upon by birds ?

Many seeds devoured by birds are voided whole: birds therefore become distributing agents of seeds, noxious and otherwise.

From the economic point of view the relationship of birds to the agriculture of the island presents so many points for consideration, that before the utility of any bird may be judged the feeding habits of that bird must be definitely known. The only sure method of determining feeding habits is by an examination of the stomach contents. The sentimental love for birds, which every one possesses, has checked any extensive investigation into this all-important subject, and the personal opinion of casual observers has, in the greater proportion of cases, been accepted as evidence in favour of the insect-feeding birds. A great deal of systematic work on the food contents of the stomachs and crops of our local insect-feeding birds is required before any particular birds can be recommended as an insect-pest reducing agent.

The following list aims at providing, in very brief form, a knowledge of the foods, manner of feeding and the nesting places of a few of the groups of the more common birds. For fuller general information in simple and accessible form the writer recommends Miss Kershaw's book *Familiar Birds of Ceylon*.

Tits.—Tree and bush feeders. Nest in holes in trees. Food: insects, seeds and fruit. The only injurious act *proved* against the tit is that of pecking the base of ripe pears and apples

(in Britain). They hunt all the year round for insects. Practical men and Ornithologists are decidedly in favour of the protection and encouragement of this bird.

Nutchats.—Tree and bush feeders. Nest in holes in trees, stumps and rocks. Food: nuts and insects. Only one species in Ceylon. Nothing known for or against its encouragement.

Babblers.—Ground feeders. Nest in trees, bushes and shrubs. Food: insects, snails (not the Kalutara variety), worms, small lizards and frogs, wild fruits and weed seeds. Harmless to vegetation.

Bulbulls.—Tree and bush feeders. Nest in trees, bushes and shrubs. Food: insects and fruits, and vegetables preferably of a red colour. Known to do considerable damage to tamatos and chillies. Eat Lantana, the seeds of which it disperses. Do good by devouring all kinds of insects.

Bush Chats.—Swoop feeders. Nest on grassy ledges and holes in banks. Eat insects by swooping and taking them on the wing. So far as is known food is entirely composed of insects. Only one Ceylon sp.

Robins.—Ground feeders. Nest in any available hole, niche or corner. Food: insects, vegetable matter and worms. Known to be beneficial in devouring injurious insects.

Blue Chats.—Ground feeders. Nest in grassy holes in banks. Food: insects, worms and weed seeds. Only one species seen in Ceylon which is a migrant from India.

Blackbirds and Thrushes.—Tree, bush and ground feeders. Nest in trees or *on* stumps, in niches and corners. Food: insects, worms, snails, berries, wild and cultivated fruits. *Blackbird* known to be a veritable plague to crops, particularly fruit, in other countries. *Thrushes* good for keeping down snails (not the Kalutara variety). Of doubtful utility.

Flycatchers.—Feed on the wing. Nests built in slender forks, or fixed to slender twigs, trees, rocks and banks. Food consists chiefly of insects, also fruit, berries and seeds. From Indian evidence of stomach and crop dissections the bird is considered to be beneficial.

Shrikes.—Tree, bush and ground and swoop feeders. Nest in bushes, forks and ledges in low trees. Food: chiefly insects. No data against their utility.

Minivets.—Tree and bush feeders. Nest high up in trees. Food: chiefly insects, also fruit and seeds. No data against their utility.

Drongos.—Swoop and ground feeders. Nest in high trees. Food: almost entirely injurious insects. Should certainly be encouraged.

Warblers: (1) **Bush Warblers.**—Mainly residents of Ceylon. Nest in thick slender bushes, reeds and grasses.

(2) **Tree Warblers.**—Migrants to Ceylon. Tree feeders.

(3) **Wren Warblers.**—Residents of Ceylon. Nest in grass and slender reeds forming ball-like nests. Bush, grass and ground feeders. Food: small insects and small seeds. May be said to be exclusively beneficial. The Tailor bird forms its nest by sewing and riveting together one, two and more leaves three to six feet from the ground.* These little birds are very numerous and are found all over the island, even in jungle, and at all elevations. Particularly obvious in and around gardens, but owing to its unobstrusive habits is seldom remarked, and in view of the fact it can be an irritatingly noisy bird it is remarkable so few people are aware of its presence around them.

Orioles.—Tree feeders. Nest at the extremities of leafy boughs. Food: insects, fruit, soft seeds and berries. May be considered beneficial.

Starlings.—(Mynas) Ground feeders. Nest in holes in trees. Food: insect, grains, wild fruit and cereals. Comparatively beneficial. The myna's aggresiveness must be considered if introducing it to a locality frequented by other and beneficial birds.

Weaver Birds.—Tree and ground feeders. Nest in trees, palms and bamboos, generally over water. Nests familiar to everyone. Food: grain and seeds. Wage war on grain crops. Not beneficial to agriculture.

Munias.—Low tree, bush and shrub feeders. Nest in creepers, bushes and grasses. Food: entirely grain, fruit and seeds. Harmful to grain and seed crops. Probable that insects are fed to nestlings but as a beneficial bird they have nothing to recommend them.

Swallows.—Feed on the wing. Nest in caves, against rocks, wood and stone walls; nests formed of mud and glued to perpendicular surfaces. Food: entirely insects. Decidedly beneficial.

Wagtails and Pippets.—Ground feeders. *Wagtails* migrants to Ceylon. Food: chiefly insects. Beneficial. *Pippets* residents. Nest in grass, reeds and reed-like bushes and shrubs. Food: insects, seeds, weeds and grasses. Nothing for or against their encouragement.

White-eyes.—Tree and bush feeders. Nest in bushes and low trees. Food: partly small insects, chiefly small buds, seeds, fruits and flowers.

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* Since the above was written the writer has watched the following unique behaviour of a pair of Tailor birds:—As soon as a Loten's Sunbird had completed the construction of its nest the pair of Tailor birds took possession of the nest, the female laid a solitary egg therein, hatched it, and raised the fledgling in the nest of the Loten's Sunbird.

As planters have frequently affirmed that this bird acts as a very important check to Tea Tortrix by devouring the moths and larvae in quantities; and have credited the bird with the ability of shaking the larvae from the flush, fuller details are here given in order that the true worth of these little birds may be juged on evidence and not on personal opinion. There are two forms of White-eye in Ceylon, the Small and the Large, both are peculiar to the island, and differ so little in size, colour, character, and habits that they may, from the point of view of their utility, be considered as one. Wait (an Ornithologist), affirms they " feed partly on insects, partly on buds and flowers." Fletcher (an Entomologist) states, " All the White-eyes are small birds, which go about in flocks, frequenting trees and bushes, whose leaves they search for small insects, varying their food at times with small buds, seeds and fruit;" and again, " The food of the White-eye consists of a mixed diet of insects and vegetable matter. Of sixteen birds examined at Pusa by the late C. W. Mason, eleven ($68\frac{3}{4}$%) contained small buds, seeds and wild fig fruits, and five ($31\frac{1}{4}$%) contained insect food consisting mostly of weevils and ants." Again he further states, " This bird . . . probably does a considerable amount of good by picking off small insects throughout the year."

The comparative size of the insect food has been stated on two occasions, namely, " *small.*" In comparison with the innumerable insects to be found in every tea bush the Tortrix moth or larva cannot be said to be a small insect. We are told that the insect food consisted mostly of weevils and ants—neither moths nor larvae.

The two hundred specimens of this bird previously mentioned and taken off Tortrix-infested areas were all White-eyes, and their stomachs contained no Tortrix.

This evidence leans to the assumption that *a lepidopterous diet is not usual to the White-eye.* Though the White-eye may be seen in flocks in tea bushes the assumption that they are devouring Tortrix moths and larvae is probably erroneous. In Ceylon up-country planting districts this little bird has been given an exaggerated reputation for devouring Tea Tortrix.

Sunbirds.—Flower feeders. Nest in bushes, low trees, ferns and palms; nests are pendant pear-shaped structures. Food: mainly nectar, and " small insects for which their long bills are admirably adapted, both mandibles being serrated along the terminal third of their length. Small spiders, caterpillars, beetles, bugs and flies, probably in most cases themselves visitors to flowers, fall a prey to these birds." (Fletcher, " Birds of an Indian Garden.") Beneficial in pollinating flowers and reducing insects.

Flowerpeckers.—Tree and bush feeders. Nests similar to Sunbirds. Food: chiefly berries; probably have the same insectivorous habits as the Sunbirds.

Pittas.—Ground feeders. Only one form in Ceylon and it is a migrant. Food: insects. Food habits little known.

Woodpeckers.—Tree feeders. Nest in holes in trees. Food: entirely insects, chiefly ants. This bird is disappointing as a devourer of injurious insects. Its chisel-like beak is so well adapted for opening the burrows of tree-boring insects, and its long worm-like tongue with its many barbed horny and sticky tip for picking up insects, that entomologists naturally feel disappointment when it is learned the bird's chief food consists of ants, that it ignores the tree-living termites and does not seek out the Black Beetle and Red Weevil from coconut and other palms.

These birds have been known to do great damage by pecking into trees, destroying seeds and barking branches, but they have also been known to destroy numbers of injurious insects which man has difficulty in doing. Fisher states, "The results of investigations into Wood-peckers tends to show that these birds by their activity in the destruction of insects, play a most useful part in nature, and should therefore be protected by foresters." (Dr. Schlich and W. R. Fisher, Manual of Forestry, Vol. IV., Forest Protection by W. R. Fisher, B.A., pp. 120-31, 1895).

Barbets.—Tree feeders. Nest in holes in trees which they excavate. Food: almost entirely fruit. Not beneficial to agriculture.

Rollers.—Tree feeders. Nest in holes in decaying trees and walls. Food: almost entirely large insects consisting of grasshoppers, crickets, beetles, caterpillars, and cutworms. Very beneficial and should be encouraged.

Bee-eaters.—Swoop feeders. Nest in burrows excavated in banks of rivers, streams, tanks, ditches and ponds. Food: exclusively insects, such beneficial insects as bees, wasps, dragonflies and parasitic hymenoptera. For these reasons it should not be encouraged. The bird is a serious pest to agriculture.

Kingfishers.—Swoop feeders. Nest in tunnels excavated in banks of rivers, streams, tanks, ditches, lagoons and ponds. Food: mostly fishes, part diet of insects.

Hoopoes.—Ground feeders. Nest in holes in trees, banks and walls. Food: insects and worms. Voracious devourers of such injurious insects as cutworms, caterpillars, crickets, grasshoppers, cock-chafers and root-eating grubs. A decidedly useful bird, and to be encouraged.

Swifts and Spinetails.—Swoop feeders. Nests in places similar to the swallow. Food: little known; casual observation would lead to the belief they feed on very small insects.

Koels and Coucals.—Ground feeders. *Koels* lay their eggs in the nests of the crow; *Coucals* nest in thick bushes and thorny trees. Food: vegetable matter, wild fruits and insects, also known to eat small frogs, lizards, mice and small birds. So far as is known neither beneficial nor injurious to agriculture.

Paroquets.—Tree feeders. Nest in trees, also holes in trees which they may either appropriate or excavate. Food: purely vegetarian, cultivated and wild grains, berries, seeds and fruits. They are most destructive to grain and fruit crops, and to trees by barking and breaking branches. To the agriculturist they are an unmitigated nuisance.

Departmental Notes.

Meetings, Conferences, Etc.

Progress Report of the Experiment Station, Peradeniya.

For the Months of January and February, 1928.

Tea.

The tea plots were again in plucking at the end of February.

The number of bushes lost after the 1927 pruning was very small.

Figures of losses after the last four prunings are given.

Plot.	Area Acres.	Number of Bushes lost after Pruning. 1921	1923	1925	1927
141 ...	1	59	3	5	5
142 ...	1	56	3	4	4
143 ...	1	69	4	44	2
144 ...	1	26	10	13	4
145 ...	1	115	13	29	5
146 ...	1	30	1	8	2
147 ...	1	28	6	11	5
148 ...	1	32	14	26	6
149 ...	1	12	7	12	2
150 ...	1	33	8	41	-
155 ...	1	Records not available		55	2
163 ...	1	,,	,,	7	2
164 ...	1	,,	,,	8	2
Hillside ...	8	,,	,,	124	7
166 ..	1	,,	,,	31	2
Half acre ...	½	,,	,,	353	3

The 1921 pruning was a severe one and was followed by dry weather. In 1925 the pruning of the Half-Acre plot was postponed from October to December and a severe drought followed. It is not possible to connect the reduction in casualties after the 1927 pruning with the presence of Indigofera since an equal reduction is found in the plots not planted with a cover crop. The improvement must rather be ascribed to the favourable weather conditions which followed pruning.

In February the Hillside tea was manured with a mixture of Synthetic urea, Superphosphate and Muriate of potash. On account of its hygroscopic nature the urea adversely affected the consistency of the mixture and it was found necessary to apply this manure separately.

An experiment in the use of Pabco Mulch Paper in a tea nursery was started in February. Four beds were made and an equal number of tea seeds sown in each bed. On two of the beds strips of Pabco Mulch Paper punched with ¾ inch holes 6 inches apart were laid and the seeds sown through these holes. After a week's dry weather the surface soil under the mulch was very moist and much moisture was condensed on the under-side of the mulch paper.

Rubber.

In plot 174 (3 1/3 acres) which was planted with budded rubber last November for an experiment on the influence of stock on scion, the situation 3 months after planting was as follows :—

52 out of 400 stocks had died and of these 45 were replaced by fresh budded plants from the nursery. Budded plants were not available to replace the other 7 plants. Of the remaining 348 plants some had shoots 18 inches high, in other cases the shoots were only one or two inches high, some were only just shooting, and some had not yet started to shoot, though the buds were still green. This irregularity is only partly due to difference in time of budding.

A good cover of *Dolichos Hosei* has now been established in the Bandaratenne rubber and an experiment has been designed to compare the effect on yield of

rubber from plots in which the cover is forked in twice a year with that from plots in which the cover is left untouched. Twelve plots arranged in randomised pairs have been laid out and the experiment is to commence on April 1st, 1928.

A census of diseases was taken in January.

Cacao.

Manures were applied to the manurial experiment plots as per plan in January.

Dadap lopping and cacao pruning was started in February.

Coffee.

The coffee interplanted in a portion of the Bandaratenne Rubber was uprooted to facilitate the carrying out of the experiment alluded to above.

Fodder Grasses.

Owing to the increasing size of the coconut palms in the plots under yield trial it has been decided that these trials shall cease on July 31st, 1928.

General.

With the completion of a new set of cooly lines an old set of wattle-and-daub lines which has been in use for many years has been demolished.

A metalled road to serve the new Cattle Shed has been completed.

The Annual report for the Station for 1927 has been compiled in new form as a separate publication and will combine the functions of a report and a guide book to the station.

T. H. HOLLAND,
Manager,
Experiment Station, Peradeniya.

Board of Agriculture.

Estates Products Committee.

Minutes of the Thirty-seventh Meeting of the Estates Products Committee of the Board of Agriculture held at the Head Office of the Department of Agriculture at 11 a.m. on Tuesday, March 13, 1928.

Present :—The Director of Agriculture (*Chairman*); The Government Agent, Central Province; The Government Mycologist; The Government Entomologist; The Government Agricultural Chemist; Messrs. R. G. Coombe; A. Coombe; L. A. Wright; J. H. Armitage; G. Pyper; G. O. Trevaldwyn; B. M. Selwyn; R. P. Gaddum; S. Pararajasingham; J. E. P. Rajapakse; C. A. M. de Silva; and T. H. Holland (*Secretary*).

Visitors :—Messrs. H. Leigh; J. W. Ferguson; and F. P. Jepson.

Letters or telegrams regretting inability to attend were received from :—

The Acting Controller of Revenue; Gate Mudaliyar A. E. Rajapakse; Messrs. I. L. Cameron; W. H. Fitzpatrick; J. Sheridan-Patterson; J. W. Scott; E. Maberley-Byrde; J. Horsfall; D. S. Cameron; H. L. De Mel; G. Pandittasekera; J. B. Coles; Hew Kennedy; C. C. du Pre Moore; and A. T. Sydney-Smith.

The minutes of the last meeting, having been circulated to members, were taken as read and confirmed.

The Chairman said that the meeting had been fixed for 11 a.m. instead of 2·30 p.m. on account of an important Planters' Association meeting at which the Director of Public Works was to be present which was fixed for the afternoon.

Mr. R. G. Coombe thanked the Chairman, on behalf of the Planters' Association, for having altered the time of the meeting at his request.

Agenda Item 1.—Progress Report of the Experiment Station, Peradeniya, for the months of January and February, 1928.

The Chairman reviewed this report.

Mr. R. G. Coombe enquired if any experiments were being conducted in "lung" pruning of tea.

The Chairman replied that in the plots under *Indigofera endecaphylla* it was necessary to adhere to the same style of pruning as was practised before the planting of the cover crop, but it was intended to start some experiments in different forms of pruning in the Hillside Tea when this was due to prune again.

Mr. Gordon Pyper asked if any experiments were in progress as to the best time to prune.

The Chairman replied that it was necessary to keep to the same time for the plots under *Indigofera*.

The Report was then adopted by the meeting.

Agenda Item 2.—Further Consideration of the question of Seed Gardens for the Rubber Industry.

The Chairman read the resolution passed on this subject at the last meeting of the Committee. He said that this resolution had been passed largely on the recommendation of Mr. C. E. A. Dias. He had since reconsidered the question and had recently had the opportunity of discussing the question with Dr. Cramer. He was now convinced that not more than two clones should be planted in one seed garden and one would be preferable. He recommended therefore that the idea of establishing a large seed garden should be abandoned and that the money should be spent on the establishment of a number of small gardens each from two to five acres in extent. He had already received an offer of five acres of land in the Kurunegala district from Mr. H. L. De Mel for this purpose.

Mr. Trevaldwyn said that this policy agree with that adopted in East Java. He considered that it would be possible to obtain these small blocks of land. He thought that he would himself be able to arrange for such a block in the Southern Province.

Mr. L. A. Wright said that he thought most members would agree with the policy now proposed by the Director.

A resolution was then passed by the meeting cancelling the resolution on seed gardens passed at the previous meeting and recommending that a sum of Rs. 47,500·00 should be allotted for the establishment of a sufficient number of small seed gardens of from two to five acres in extent on the lines laid down in the memorandum submitted by the Director of Agriculture to the January meeting of the Committe.

Agenda Item 3.—Proposals for the Planting of the Iriyagama Division of the Experiment Station, Peradeniya, with Budded Rubber.

Mr. Holland read these proposals.

The Chairman made a few explanatory remarks and recapitulated the objects of the Scheme.

Mr. R. P. Gaddum enquired if it was the intention to hole before digging the terraces, or to terrace first.

Mr. Holland said that this point had not been discussed as yet.

Mr. Gaddum thought that it was preferable to hole first. He also mentioned the desirability of leaving small transverse bunds across the terraces to prevent the lateral movement of water.

The proposals were adopted by the meeting.

Agenda Item 4.—Chilaw Coconut Experiments.

The Chairman reviewed this report.

Mr. J. E. P. Rajapakse enquired whether any changes in the treatment of the plots were contemplated.

The Chairman replied that changes had been made in 1925 and he did not consider it advisable to make any further changes at least for five years from that date.

Mr. Rajapakse said that it was his experience that plots which were frequently cultivated were liable to deteriorate after about 10 years, even though they received manures. He enquired whether *Vigna* would grow at Chilaw.

The Chairman said he would prefer to await the results of a trial with this cover crop. There was also a similar plant, *Vigna marina* which might be useful for a sea coast district.

Mr. C. A. M. de Silva said that *Vigna* grew well at Chilaw.

The meeting agreed to the publication of the report in the *Tropical Agriculturist.*

Agenda Item 5.—Report on Alexandra Estate Coconut Experiments.

The Chairman announced that Mr. J. E. P. Rajapakse had been unable to submit this report as all the copra was not yet cured.

Mr. J. E. P. Rajapakse said he hoped to be able to submit the report in the course of a few days.

Agenda Item 6.—Consideration of Tea Tortrix Returns.

The Chairman commented on the tables of figures which had been circulated to members. It had been brought to his notice that the most efficacious way of destroying *larvae* and *pupae* was to crush them in the field and therefore that the compilation of returns of *larvae* and *pupae* destroyed was not practicable.

The Dickoya District Planters' Association had unanimously voted in favour of the deletion of the portion of the rules relating to *larvae* and *pupae* and he asked the opinion of the meeting on this point.

The meeting agreed that steps should be taken to have the Rules of the Ordinance amended so that returns of *larvae* and *pupae* destroyed should not be required.

Mr. R. G. Coombe enquired whether it was intended to make the collection of egg masses compulsory on Estates where tortrix was heavily parasitized.

The Chairman said that it was considered that for the present the rules should be enforced as they stood. He knew of an estate where Tortrix was parasitized where the Superintendent had had cages constructed which would admit the escape of the parasite but not the pest, and all egg masses were put into these cages.

In conclusion the Chairman mentioned that owing to the Agricultural Conference it was improbable that a meeting of the Committee would be held in May.

T. H. HOLLAND,
Secretary,
Estates Products Committee,
Peradeniya.

Power Alcohol from Grasses, Straws and Waste Vegetable Materials.

The Fuel Research Board of the Department of Scientific and Industrial Research has issued a memorandum indicating the position of the Empire in regard to supplies of petrol as a fuel for internal-combustion engines, and the investigations which have been made into the possibilities of producing alternative fuels, were particularly alcohol.

This memorandum indicates that the main sources of alcohol are vegetable materials containing sugar or starch and that the question of the price that could be paid for alcohol for power purposes depended upon the price of petrol. The production of alcohol in any considerable quantities from vegetable materials grown in the United Kingdom is not economically possible owing to (1) insufficient acreage, (2) the high cost of cultivation and harvesting, (3) the high cost of manufacture and (4) the fact that the most suitable raw materials are also important foodstuffs. The possibilities of producing power alcohol from materials rich in starch in other parts of the Empire have also been investigated and the general conclusion arrived at was that there are possibilities in making alcohol from molasses when it is available and from suitable crops cultivated for the purpose. The position is now similar to what it was in 1921, but in Queensland a factory has been erected and has started to work with waste molasses as the raw material and it is intended to supplement the molasses with maize and possibly other similar crops grown specially for the purpose. Alcohol can also be produced from the cellulose of plants by its direct fermentation, or by converting the cellulose into fermentable matter by chemical processes. Large quantities of cellulosic materials, constantly renewed by nature, are available and are of little or no commercial value. They offer a possible solution provided that a practicable and economic method of treating them could be discovered. There are vast quantities of tropical and sub-tropical vegetation—such as grasses, maize and rice straw, maize cobs, rice husks, sisal hemp waste—available. Twenty-seven of such materials have been experimented upon. Sulphuric and oxalic acids were used as hydrolysing agents. In the case of sisal hemp residue, rice straw and Nile Sudd, the rate of fermentation was found to proceed at a maximum without the addition of food substances, whilst maize cobs undoubtedly required additional nitrogen to secure a complete fermentation.

The experimental work on a semi-technical scale has demonstrated the technical practicability of converting waste vegetable matter into liquid fuels suitable for use in internal-combustion engines and has enabled a general idea to be obtained of the lines on which a suitable plant for large scale production might be constructed. If the cost of waste vegetable matter is 10 shillings per ton, the cost per gallon of liquid fuel is 8 pence and so on in proportion.

There are no real technical difficulties once the raw materials are available in sufficient quantity and at a sufficiently low cost. Where waste vegetable materials can be treated at their source without further expense of collection, it appears that their conversion into alcohol for use in internal combustion engines is worthy of investigation, but the question of grasses is a somewhat different one owing to the fact that the cost of harvesting and transporting might make their use economically impossible.

F. A. S.

What the Plant Breeder has done for Canadian Wheat Growing.

Even in this comparatively enlightened age governments are sometimes reluctant to grant funds for purposes of agricultural research yet the financial benefits derived from such research may often be out of all proportion to the cost. An example of the benefits of one form of agricultural research is given in a recent pamphlet* issued by the Department of Agriculture of the Dominion of Canada. The author estimates that the adoption of the well-known Marquis wheat enables the Dominion to realize annually £ 20,000,000 more from its wheat crop. Marquis wheat originated as the result of a cross between the varieties Red Fife and Ladoga made at the Central Experimental Farm at Ottawa in 1892. The progeny of the cross was examined by the Dominion Cerealist in 1903 and a number of the most promising "lines" which were similar in essential characters were bulked together and after further testing received the name of Marquis. The variety was introduced to the farmer about 1909 and by 1915 it was estimated that 90 per cent. of the area of spring wheat was sown with Marquis. It is assumed that at the present time the area under Marquis is 15,000,000 acres and that on an average the increased yield per acre is five bushels. In this book *Science Old and New* Professor J. A. Thompson writing of the romance of wheat quotes the following sentence: "The first crop of the wheat Marquis that was destined within a dozen years to overtax the mightiest elevators in the land was stored away in the winter of 1904-5 in a paper packet no larger than an envelope."

There are no fifteen million acres of wheat in Ceylon but there are over 800,000 acres of rice. If this area were sown with selected strains of rice which produced no more than an additional two bushels per acre the increased financial return to the Colony would be more than Rs. 3,000,000.

In the interesting pamphlet under review, whilst discussing the work of the plant breeder the author says:

"The rise to prominence of Canada, as a wheat-growing country, has been made possible in no small degree by the work of the plant-breeder. It is probably safe to say that in few countries, if any, has the work of the scientific breeder of plants contributed more directly and substantially to national prosperity than it has in Canada. He has given to Canada varieties of wheat which have added millions of dollars annually to the value of Canadian production and has turned what was once a distinctly hazardous occupation throughout vast areas of Western Canada into a relatively safe and profitable enterprise."

In Ceylon also, appreciable benefits are possible by the breeding or selection of superior strains of rice but results cannot be obtained to order and the process of isolating and testing superior strains will take many years. Unfortunately in Ceylon there are few large areas with similar climatic conditions and the wide range of climatic conditions under which rice is grown makes the problem of the plant-breeder more difficult. There is no doubt, however, that in course of time, improved strains can be isolated suitable for all the varying conditions and that what has happened in Canada can be repeated, though on a smaller scale, in Ceylon.

L. L.

* "The History and Present Status of Wheat Production in Canada" by L. H. Newman, Dominion of Canada, Dept. of Agriculture Phamphlet No. 89. 1928.

Imperial Institute, South Kensington, London, S. W., 7.

Report on Kapok from Ceylon.

THE sample of kapok which is the subject of this report was received for examination at the Imperial Institute on the 21st November from the Director of Agriculture, and is referred to in his letter No. A. 571 dated the 7th October, 1927.

It was stated that the sample consisted of hand-cleaned floss of Java kapok grown at one of the Experiment Stations of the Agricultural Department and that it had been specially cleaned in the hope that it might approximate more closely to the good Java type than did the previous sample which was the subject of Imperial Institute report dated the 23rd June, 1927.

Description.

The sample weighed 11½ lbs. and consisted of soft, lustrous floss of dark cream colour and rather lumpy appearance. It bore very slight, occasional stains and contained a few seeds and fragments of pod cases. The fibre was cleaner and of slightly paler colour than the sample reported on previously.

Results of Examination.

On examination the fibres were found to have the following dimensions, which are shown in comparison with those of the earlier sample and those obtained from a commercial sample of "prime" Java kapok:—

	Length in inches.			Diameter in inches.		
	Present Sample from Ceylon.	Previous Sample from Ceylon.	Java Kapok.	Present Sample from Ceylon.	Previous Sample from Ceylon.	Java Kapok.
Maximum	1·1	1·0	1·1	0·0014	0·0010	0·0010
Minimum	0·4	0·3	0·5	0·0005	0·0004	0·0006
Mostly	0·6-0·9	0·6-0·8	0·7-0·9	0·0006-0·0009	0·0007-0·0008	0·0008-0·0009
Average	0·7	0·7	0·8	0·0008	0·00072	0·0008

These results show that the fibres of the present sample are of the same average length and approximately of the diameter as those of the previous sample from Ceylon but are slightly shorter than those of Java kapok.

Commercial Value.

A portion of the sample was submitted to Messrs. Bastone and Firminger, one of the commercial firms who had reported on the earlier sample. They reported that it consisted of "extremely well-cleaned, fine, bright-coloured, knobbly Ceylon kapok of usual resiliency, inclined to be rather piecey. Practically free from seed and other impurities. Well above the fair average quality of the past season. Value 11½*d* per lb. c.i.f. "if packed in light pressed bales." Prime Java kapok was quoted in London on the same date at 1*s* 1*d* per lb. c.i.f.

The firm stated that in order to compete closely with Java kapok in the market the product should resemble the latter more in staple and should not be so "piecey" as the present sample. The difference however may be due to the difference in the climatic conditions of Ceylon and Java. The lower value of the Ceylon product is caused by the fact that for cushion-stuffing 1 lb. of the Ceylon kapok does not go as far as 1 lb. of the Java material. The firm added that the present sample showed a considerable improvement in respect of uniformity of colour and had been better cleaned than any sample of Ceylon kapok they had seen previously. In these two directions therefore definite progress has been made.

Remarks.

This sample of kapok was cleaner, better prepared and somewhat paler and more uniform in colour than the earlier sample, but showed the same lumpy and knobbly appearance. It seems not improbable that the difference in the appearance of Ceylon and Java kapok may be due to climatic influences, which in the case of Ceylon may perhaps prevent the fibre after leaving the pod from opening out so readily and completely as it does in Java.

29th December, 1927.

School Garden Competition in Kalutara District.

A School garden competition was held in the Kalutara district for prizes of Rs. 100·00 and Rs. 50·00 offered respectively by Mudaliyar W. Daniel Fernando Waidyasekera of Panadura and Mr. E. S. A. Samaranayake of Horana.

2. Several gardens entered the competition and the following have been adjudged winners of prizes.

Ittepana, B.V.S.
Rakandalagoda, B.V.S.
Kovitiyagala, B.V.S.
Migahatenna, B.V.S.
Agalawatte, B.V.S.
Bellana, B.V.S.

Home Garden Competition in Pasdun Korale West.

A home garden competition in Pasdun Korale West, for 1927-28, was held for a prize of Rs. 50:00 offered by Mr. W. R. de Alwis Seneviratne of Matugama. Several competitors entered and the following have been adjudged winners:—

1. William of KL/Walallawita B.
2. Velu Singho of KL/Ittepana, B.
3. L. A. Adilin Nona of KL/Iddegoda, M.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st MARCH, 1928.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st, 1928	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	360	275	203	1	156	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis.	4	...	3	1	...	...
	Rabies (Dogs)	1	...	...	...	...	1
Colombo Municipality	Rinderpest	34	34	...	28	5	1
	Foot-and-mouth disease	244	86	212	9	23	...
	Anthrax	1	...	...	1	...	...
	Rabies (Dogs)	4	1	...	...	...	4
Cattle Quarantine Station	Rinderpest	33	33	5	14	14	...
	Foot-and-mouth disease	50	33	47	3	...	...
	Anthrax	...	...	...	...	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	50	3	42	...	8	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	2	2	...	...	...	2
Southern	Rinderpest	FREE					
	Foot-and-mouth disease						
	Surra						
Northern	Rinderpest	FREE					
	Foot-and-mouth disease						
	Piroplasmosis						
	Rabies (Dogs)						
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	5	...	5	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis						
North-Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	214	108	159	2	53	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis						
	Rabies (Dogs)						
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	298	268	230	...	68	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and mouth disease	8	...	8	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis						
	Rabies (Dogs)						
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	5	...	5	...	...	...
	Anthrax	...	...	...	...	...	...

MARTIN WIJAYANAYAKA,
For Government Veterinary Surgeon.

Colombo, 13th March, 1928.

METEOROLOGICAL

MARCH, 1928.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction During Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	81·0	—0·4	77	5·2	W	90	3·65	7	— 1·13
Puttalam	80·6	—0·6	74	2·0	Var	104	0·77	2	— 2·28
Mannar	82·9	—0·1	69	3·5	Var	171	0·26	1	— 1·25
Jaffna	80·4	—2·4	76	3·2	ESE	122	0	0	— 1·22
Trincomalee	80·8	—1·8	76	3·2	NE	90	0·53	3	— 1·24
Batticaloa	80·6	—0·2	78	3·5	NNE	169	0·01	1	— 3·24
Hambantota	80·9	+0·5	76	3·8	Var	266	2·00	4	— 0·50
Galle	81·2	+0·1	78	4·0	WNW	139	4·77	9	+ 0·10
Ratnapura	84·0	+1·8	71	4·2	—	—	4·03	13	— 5·10
Anu'pura	81·2	—0·8	67	4·6	—	—	3·08	6	+ 0·22
Kurunegala	82·1	—0·7	68	5·8	—	—	6·44	5	+ 1·21
Kandy	80·6	+2·3	64	3·9	—	—	6·78	7	+ 2·75
Badulla	73·0	—0·4	75	3·6	—	—	2·20	3	— 2·44
Diyatalawa	66·8	—0·9	72	4·8	—	—	3·34	6	— 1·02
Hakgala	62·8	+2·4	74	3·8	—	—	4·96	7	— 0·57
N'Eliya	58·2	—1·0	68	5·0	—	—	5·90	8	+ 2·45

The rainfall of March was deficient over nearly the whole island. The first fortnight was particularly dry and had the further disadvantage of following a dry February. Rain was fairly general in the southern half of the island on March 15th-18th after which the next week was again almost dry. There was considerable rain during the last few days, largely in the form of thunderstorms, but the change came too late to bring the totals for the month up to average in more than a few cases.

The areas that reached their average can be summarised roughly as from Kandy northwards through Matale and Dambulla to Kanthalai and Horawapotana, and from Deniyaya northwood through Pelmadulla and Carney to Maliboda.

The highest fall recorded in 24 hours was 6·79 inches at Galawela on the 15th. Other falls of over 5 inches were at Horawapotana, Carney, Hiniduma, and Moratuwa.

In several cases the day temperatures were considerably above their average and the night ones below theirs. As a result the column in the table above which gives the mean of these variations affords a rather inadequate description of the actual conditions. Ratnapura reported 98°3 on the 2nd which is just above the highest temperature recorded by any station in 1927.

A. J. BAMFORD,